433-MAR-0001

GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST) PROJECT

MISSION ASSURANCE REQUIREMENTS (MAR) FOR THE LARGE AREA TELESCOPE (LAT)

OCTOBER 26, 2000

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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NASA Goddard Space Flight Center

Greenbelt, Maryland

GLAST Project Mission Assurance Requirements (MAR) for the Large Area Telescope (LAT)

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CHAPTER 1. Overall Requirements

1.0 OVERVIEW OF CHAPTER 1

Chapter 1 addresses the overall program requirements including the justification of "heritage" or previously designed, fabricated, or flown hardware; surveillance of the contractor; applicable documents (Chapter 13); document acronyms and glossary (Chapter 14); and recommended documentation (RD's) for the developer's consideration and/or clarification (Chapter 15). The LAT Contract Delivery Requirement List (CDRL) identifies those deliverables that will be part of the System Safety and Mission Assurance Program for the Large Area Telescope.

The deliverable items (DID's) and reference items (RD's) related to this chapter are:

Item	DID/RD No.	MAR Reference Sections	Notes
Performance Assurance Implementation Plan (PAIP) or Performance Assurance Plan (PAP)	DID 301	1.1, 2.1, 6.1, 7.1, 10.1, 12.1	May include other plans referenced in this document including the System Safety Plan, the EEE Parts Control Program Plan, the Material and Processes Program Plan, and the Risk Management Plan.
Use of Multi-Mission or Previously Designed, Fabricated, or Flown Hardware	RD 1-1	1.2	
Electronic Copies of Requirements Documents	DID 302	1.10	

1.1 DESCRIPTION OF OVERALL REQUIREMENTS

The developer is required to plan and implement an organized System Safety and Mission Assurance Program that encompasses (1) all flight hardware, either designed/built by developer or furnished by the Government, from project initiation through launch operations, , (2) to the extent necessary to assure the integrity and safety of flight items, the ground system that interfaces with flight equipment items, and (3) all software critical for mission success. This plan shall be documented in a Performance Assurance Implementation Plan (PAIP) or Performance Assurance Plan (PAP). (Refer to the CDRL, DID 301.)

Managers of the assurance activities will have direct access to developer management independent of project management, with the functional freedom and authority to interact with all other elements of the project. Issues requiring project management attention should be addressed with the developer(s) through the Project Manager(s) and/or Contracting Officer Technical Representative(s).

The Systems Safety and Mission Assurance Program is applicable to the project and its associated contractors, subcontractors, and developers.

1.2 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

When hardware that was designed, fabricated, or flown on a previous project is considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated, the developer will be required demonstrate how the hardware complies with requirements prior to being relieved from performing any tasks. (Refer to Chapter 15, RD 1-1.)

1.3 SURVEILLANCE OF THE CONTRACTOR

The work activities, operations, and documentation performed by the developer or his suppliers are subject to evaluation, review, audit, and inspection by government-designated representatives from GSFC, the Government Inspection Agency (GIA), or an independent assurance contractor (IAC). GSFC will delegate in-plant responsibilities and authority to those agencies via a letter of delegation, or the GSFC contract with the IAC.

The developer, upon request, will provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. The developer will also provide the government assurance representative(s) with an acceptable work area within developer facilities.

1.4 APPLICABLE DOCUMENTS (CHAPTER 13)

To the extent referenced herein, applicable portions of the documents listed in Chapter 14 form a part of this document.

1.5 ACRONYMS AND GLOSSARY (CHAPTER 14)

Chapter 15 defines acronyms and terms as applied in this document.

1.6 CONTRACT DELIVERY REQUIREMENTS LIST (CDRL)

The CDRL contains Data Item Descriptions (DID's) which describe data deliverable to the GSFC Project Office. The "DID numbers" cited in this document refer to the "CDRL numbers" listed on the DID's contained in the CDRL. Deliverables may be received/reviewed by GSFC personnel at either GSFC or at the developer's facility as specified in the respective DID.

The following definitions apply with respect to assurance deliverables:

Deliver for Approval:	Documents in this category require written GSFC approval prior to use. Requirements for resubmission shall be as specified in the letter(s) of disapproval.
Deliver for Information/Review:	Documents in this category require receipt by GSFC for the purpose of determining current program status, progress, and future planning requirements. When Government evaluations reveal inadequacies, the developer will be directed to correct the documents.

1.7 RECOMMENDED DOCUMENTATION (CHAPTER 15)

Recommended documentation (RD's) is identified in Chapter 15. These are items that GSFC recommends the developer prepare; however, they are not mandatory deliverables. If requested and the developer has performed that task, the developer will make the information indicated in the RD available to the GSFC Project Office. (See "Preface" for Chapter 15.)

1.8 ADDENDUM A: GROUND DATA SYSTEMS ASSURANCE REQUIREMENTS

The ground data systems assurance requirements will be described in this pending addendum which will be negotiated at a later date.

1.9 ADDENDUM B: S&MA DELIVERABLES NOT COVERED IN THE CDRL

The deliverable items whose first delivery is not required until after PDR are described in this addendum. These items will be added to the CDRL for the LAT follow-on contract (GSFC 433-CDRL-0001). They are listed here for the convenience of MAR readers.

1.10 REQUIREMENTS DOCUMENTS

All developer-prepared equirements documents such as the instrument specification, the instrument performance verification plan, and the PAIP and its associated documentation such as the Risk Management Plan and System Safety Program Plan will be delivered electronically to the GSFC Project Office for analysis. (See the CDRL, DID 302.) The documents will be analyzed using the Automated Requirement Measurement (ARM) Tool that was developed at GSFC for use as an early life cycle aid to identify areas of a requirements specification document that can be improved. (Note: GSFC-prepared requirements documents will be analyzed using the same ARM Tool.)

CHAPTER 2. System Safety Requirements

2.0 OVERVIEW OF CHAPTER 2

Chapter 2 addresses the System Safety Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) related to this chapter are:

Item	DID No./ Addendum B Item No.	MAR Reference Sections	Notes
System Safety Program Plan (SSPP)	DID 303	2.1, 2.2	May be incorporated into the developer's PAIP.
Preliminary Hazard Analysis (PHA)	DID 304	2.2	
Operating & Support Hazard Analysis (O&SHA)	Item 1	2.2	
Hazard Control Verification Log	Item 2	2.2	
Safety Assessment Report (SAR)	Item 3	2.2	
Ground Operations Plan Inputs	Item 4	2.2	
Safety Noncompliance Reports	DID 305	2.2	

2.1 SYSTEM SAFETY REQUIREMENTS

Flight hardware and software systems developers shall implement a system safety program in accordance with the requirements imposed by the appropriate launch range and the launch vehicle manufacturer or launch service provider. The requirements may be tailored the specific mission with the concurrence of the applicable launch range safety organization.

The developer will prepare a System Safety Program Plan (SSPP) which will describe their system safety program within their facility and, to the extent required, at the spacecraft integrator's facility and the launch facilities. (Refer to the CDRL, DID 303.) The SSPP may be incorporated into the Performance Assurance Implementation Plan. (Refer to the CDRL, DID 301.) The safety program will be in accordance with the requirements of EWR 127-1 and KHB 1710.2D.

The following are mandatory compliance requirements for hardware and software to be launched out of the Eastern Range on any of the various launch vehicles/launch services. The Project Manager ensures compliance with the requirements and certifies to the launch range, in the form of the Safety Data Package, that all of the requirements have been met.

Top level Safety Requirements documents for the GLAST launch are:

a. EWR 127-1, "Eastern and Western Range Safety Requirements" which defines the Range Safety Program responsibilities and authorities and which delineates policies, processes, and approvals for all activities from the design concept through test, check-out, assembly, and the launch of launch vehicles and payloads to orbital insertion or impact from or onto the Eastern Range (ER) or the Western Range (WR). It also establishes minimum design, test, inspection, and data requirements for hazardous and safety critical launch vehicles, payloads, and ground support equipment, systems, and materials for ER/WR users.

b. KHB 1710.2C, "Kennedy Space Center Safety Practices Handbook" which specifies and establishes safety policies and requirements essential during design, operation, and maintenance activities at KSC and other areas where KSC has jurisdiction.

As appropriate, any testing performed at GSFC will comply with the safety requirements contained in 5405-048-98, the Mechanical Systems Center Safety Manual.

Satisfactory compliance with the above requirements is required to gain payload access to the launch site and the subsequent launch.

The developer will participate in Project activities associated with compliance to NPD 8710.3, NASA Policy for Limiting Orbital Debris Generation. Design and safety activities will take into account the instrument's impact on the spacecraft's ability to conform to debris generation requirements.

2.2 SYSTEM SAFETY DELIVERABLES

Refer to the CDRL, DID's 303 through 305 as well as to Addendum B Items 1 though 4 for the System Safety deliverables.

CHAPTER 3. Technical Review Requirements

3.0 OVERVIEW OF CHAPTER 3

Chapter 3 addresses the Technical Review Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) related to this chapter are:

Items	DID No.	MAR Reference Sections	Notes
Instrument Systems Requirement Review (SRR)	306	3.2, 3.4.2.2, 3.4.2.3	The deliverables for each of these instrument level reviews include: • The presentation package • Supporting data • Technical and logistics support
Instrument Preliminary Design Review (PDR)			
Software PDR (may be part of PDR)			
Instrument Critical Design Review (CDR)			
Software CDR (may be part of CDR)			
Instrument Pre-Environmental Review (PER)			
Mission SRR		3.2, 3.4.2.2, 3.4.2.4, 3.4.2.6	The developer's level of participation will be determined by GSFC Project Office and/or spacecraft contractor. Developer inputs will be blended into deliverables.
Mission PDR			
Mission CDR			
Observatory PER		3.2, 3.4.2.2, 3.4.2.4	
Observatory PSR			
Mission Operations Review		3.2, 3.4.2.2, 3.4.2.4, 3.4.2.6	
Flight Operations Review			
Launch Readiness Review			
Safety Reviews		3.4.4	
Component and Subsystem Peer Reviews including Packaging Reviews		3.5	Reports only are deliverable.
Invitation to Peer/Packaging Review			

3.1 GENERAL REQUIREMENTS

The developer will support a series of comprehensive system-level design reviews that are conducted by the GSFC Systems Review Office (SRO). The reviews cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility. (See Section 3.3.) In addition, each developer will conduct a program of planned, scheduled and documented component and subsystem reviews of all aspects of his area of responsibility. (Refer to CDRL, DID 306.)

3.2 GSFC SYSTEM REVIEW REQUIREMENTS

For each specified system-level review conducted by the GSFC SRO, the developer will:

a. Develop and organize material for oral presentation to the GSFC review team. Copies of the presentation material will be available at each review.

b. Support splinter review meetings resulting from the major review.

c. Produce written responses to recommendations and action items resulting from the review.

d. Summarize, as appropriate, the results of the Developer Reviews at the component and subsystem level.

3.3 GSFC SYSTEM REVIEW PROGRAM

The Office of Systems Safety and Mission Assurance (OSSMA) System Review Program (SRP) guidelines consists of individual, periodic reviews of all GSFC managed flight missions, flight instruments, flight spacecraft, ground systems which interface with flight hardware, unique flight support equipment, and their associated software including hardware supplied to GSFC-managed flight missions by other organizations or by another NASA Center.

3.4 IMPLEMENTATION

3.4.1 System Review Program (SRP)

The primary objective of the SRP is to enhance the probability of success of GSFC missions. This objective will be achieved by bringing to bear on each GSFC-managed flight mission the cumulative knowledge of a team of engineers and scientists who have had extensive prior experience with the particular types of systems and functions involved. While the design review is technically oriented, proper consideration will be given to constraints operating on the mission. These reviews will assure that each mission has the benefit of Center-wide experience gained on other missions.

3.4.2 Structure and Function of the System Review Program

3.4.2.1 System Review Plan

The Chief of the SRO, in conjunction with the individual Project Manager, and/or Principal Investigator (PI) will develop system review requirements to be documented in the project mission assurance requirements. The Chief of the SRO may waive the requirement for some of these reviews based primarily on considerations of system complexity, criticality, extent of technological design, (e.g., state-of-the-art), previous flight history, mission objectives, and any mandated constraints.

3.4.2.2 The System Review Team (SRT)

The SRT will include personnel experienced in subsystem design, systems engineering and integration, testing, and all other applicable disciplines. The review chairperson, in concert with the Project Manager and/or PI, and other Directorates, appoints independent key technical experts as review team members. Personnel outside the Center may be invited as members or co-chairperson of the SRT if it is felt their expertise will enhance the SRT. The reviews will be based upon an appropriate selection from the following system reviews:

a. System Requirements Review (SRR)--This review is keyed to the beginning of the design, assembly, and test phase to verify that the appropriate plans and requirement specifications are in place, well documented, and understood by all parties.

b. Preliminary Design Review (PDR)--This review occurs early in the design phase by prior to manufacture of engineering hardware and the detail design of associated software. Where applicable, it should include the results of test bedding, breadboard testing, and software prototyping. It should also include the status of the progress in complying with the launch range safety requirements. At PDR the flight hardware developer should have identified and documented all of the hazards associated with the flight hardware.

c. Critical Design Review (CDR)--This review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. It will emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing. The developer is also required to present the status of the controls for the safety hazards presented in the PDR and the status of all presentations to the launch range.

d. Mission Operations Review (MOR)--This mission-oriented review will normally take place prior to significant integration and test of the flight system and ground system. Its purpose is to review the status of the system components, including the ground system and its operational interface with the flight system. Discussions will include mission integration, test planning and the status of preparations for flight operations.

e. Pre-Environmental Review (PER)--This review occurs prior to the start of environmental testing of the protoflight or flight system. The primary purpose of this review is to establish the readiness of the system for test and evaluate the environmental test plans.

f. Pre-Shipment Review (PSR)--This review will take place prior to shipment of the instrument for integration with the spacecraft and for shipment of the spacecraft to the launch range. The PSR will concentrate on system performance during qualification or acceptance testing. The flight hardware developer is also required to present the status of the tracking of the safety items listed in the validation tracking log, the status of deliverable documents to the launch range and the status of presentations and any subsequent launch range issues or approvals prior to sending flight hardware to the range.

g. Flight Operations Review (FOR)--While all of the previous reviews involve operations, this review will emphasize the final orbital operation plans as well as the compatibility of the flight components with ground support equipment and ground network, including summary results of the network compatibility tests.

h. Launch Readiness Review (LRR)--This review is to assess the overall readiness of the total system to support the flight objectives of the mission. The LRR is usually held at the launch site 2 to 3 days prior to launch.

3.4.2.3 The SRP for each instrument will consist of SRR, PDR, CDR, PER, and PSR.

The GSFC policies and practices will not be imposed on instruments provided by other NASA Centers that are not in-line with mission success. The other NASA Centers will have the sole responsibility for their instruments' performance and longevity. GSFC will only insure system safety and that the system interfaces are such that an instrument failure will not adversely affect other elements of the spacecraft or GSE.

The review program for instruments provided by the other NASA Centers that are in-line with mission success will tailored as appropriate.

3.4.2.4 The SRP for each spacecraft will generally consist of SRR, PDR, CDR, MOR, PER, PSR, FOR, and LRR. Instrument contractor personnel shall attend and participate in these reviews to the extent required.

3.4.2.5 The SRP for flight equipment supplied to GSFC by another organization (non-NASA or JPL) will be treated as if it were GSFC equipment to fly on a GSFC spacecraft and will be subject to the requisite GSFC review program.

In the event that the other organization has an independent review program equivalent to the GSFC program, their program may be substituted after supplying acceptable justification to the Chief of the SRO.

Tailoring of the review program is permitted by mutual agreement to meet the intent of the GSFC SRP. Tailoring is subject to approval of the Chief of the SRO.

3.4.2.6 The SRP for new, project unique ground systems will consist of PDR and CDR. The ground system is also a major subject of the mission-oriented reviews SRR, MOR, FOR, and LRR. Instrument contractor personnel shall attend and participate in these reviews to the extent required.

Generic mission operations and data systems facilities newly developed or significantly modified will normally be reviewed by an appropriate Directorate review team.

Readiness of the "new" system for mission support will be reviewed through the mission LRR conducted by the SRO the first time the generic system is to be used in a prime support mode.

3.4.3 System Review Schedule

The system reviews will be conducted on a schedule determined by the Chief, SRO, after consultation with the appropriate Project Manager and/or PI.

3.4.4 System Safety

The safety aspects of the systems being reviewed are a normal consideration in the system evaluations conducted by the SRP. At each appropriate review, the project will demonstrate understanding of and compliance with the applicable launch range requirements, list any known noncompliance's and provide justification for any expected waiver conditions. In addition, the project will present the results of any safety reviews held with the Eastern Test Range.

3.5 DEVELOPER REVIEW REQUIREMENTS

The developer will implement a program of peer reviews for missions at the component and subsystem levels. The program will, as a minimum, consist of a Preliminary Design Review and a Critical Design Review. In addition, packaging reviews will be conducted on all electrical and electromechanical components in the flight system.

The PDR and CDR will evaluate the ability of the component or subsystem to successfully perform its function under operating and environmental conditions during both testing and flight. The results of parts stress analyses and component packaging reviews, including the results of associated tests and analyses, will be discussed at the component PDR's and CDR's.

The packaging reviews will specifically address the following:

a. Placement, mounting, and interconnection of EEE parts on circuit boards or substrates.

b. Structural support and thermal accommodation of the boards and substrates and their interconnections in the component design.

c. Provisions for protection of the parts and ease of inspection.

Developer reviews will be conducted by personnel who are not directly responsible for design of the hardware under review. GSFC reserves the right to attend the peer reviews and requires 10 working days notification. The results of the reviews will be documented and the documents will be made available for review at the developer's facility.

CHAPTER 4. Design Verification Requirements

4.0 OVERVIEW OF CHAPTER 4

Chapter 4 addresses the Design Verification Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) related to this chapter are:

Items	DID No./ Addendum B Item No.	MAR Reference Sections	Notes
Instrument Performance Verification Plan	DID 307	4.2.1	
Environmental Verification Plan	DID 307	4.2.1.1	These items may each be a section of DID 307 or a freestanding document.
Performance Verification Matrix	DID 307	4.2.1.2	
Environmental Test Matrix (ETM)	DID 307	4.2.1.3	
Environmental Verification Specification	DID 307	4.2.1.4	
Performance Verification Procedures	Item 5	4.2.2	
Verification Reports	Item 6	4.2.3	
Instrument Performance Verification Reports	Item 6	4.2.3	

4.1 GENERAL REQUIREMENTS

A system performance verification program documenting the overall verification plan, implementation, and results is required to ensure that the payload meets the specified mission requirements, and to provide traceability from mission specification requirements to launch and on-orbit capability. The program consists of a series of functional demonstrations, analytical investigations, physical property measurements, and tests that simulate the environments encountered during handling and transportation, pre-launch, launch, in-orbit, and, where appropriate, retrieval, reentry, and landing. All prototype or protoflight hardware will undergo qualification to demonstrate compliance with the verification requirements of this section. In addition, all other hardware (flight, follow-on, spare, and re-flight as defined in Chapter 15 "Hardware") will undergo acceptance in accordance with the verification requirements of this chapter.

The Verification Program begins with functional testing of assemblies. It continues through functional and environmental testing supported by appropriate analysis, at the unit/component, subsystem/instrument, and spacecraft/payload levels of assembly. The program concludes with end-to-end testing of the entire operational system including the payload, the Payload Operations Control Center (POCC), and the appropriate network elements.

The General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components (GEVS-SE) (Refer to Chapter 3.), should be used as a baseline guide for developing the verification program. Alternative methods are acceptable provided that the net result demonstrates compliance with the intent of the requirements.

4.2 DOCUMENTATION REQUIREMENTS

The following documentation requirements should be tailored to meet project needs, and will be delivered and approved in accordance with the Contract Schedule.

4.2.1 Performance Verification Plan

An instrument performance verification plan (Refer to the CDRL, DID 307.) will be prepared defining the tasks and methods required to determine the ability of the instrument to meet each project-level performance requirement (structural, thermal, optical, electrical, guidance/control, RF/telemetry, science, mission operational, etc.) and to measure specification compliance. Limitations in the ability to verify any performance requirement will be addressed, including the addition of supplemental tests and/or analyses that will be performed and a risk assessment of the inability to verify the requirement.

The plan will address how compliance with each specification requirement will be verified. If verification relies on the results of measurements and/or analyses performed at lower (or other) levels of assembly, this dependence will be described.

For each analysis activity, the plan will include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity, if any, and requirements for reports. Analysis results will take into account tolerance build-ups in the parameters being used.

The following documents may be included as part of the Instrument Performance Verification Plan or as separate documents to meet project needs.

4.2.1.1 Environmental Verification Plan

An environmental verification plan will be prepared, as part of the System Verification Plan or as a separate document, that prescribes the tests and analyses that will collectively demonstrate that the hardware and software comply with the environmental verification requirements.

The environmental verification plan will provide the overall approach to accomplishing the environmental verification program. For each test, it will include the level of assembly, the configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, necessary functional operations, personnel responsibilities, and requirement for procedures and reports. It will also define a rationale for retest determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity will be described.

Limitations in the environmental verification program that preclude the verification by test of any system requirement will be documented. Alternative tests and analyses will be evaluated and implemented as appropriate, and an assessment of project risk will be included in the Instrument Performance Verification Plan.

Because of the intended tailoring of the verification program, the preliminary plan must provide sufficient verification philosophy and detail to allow assessment of the program. For example, for the environmental test portion of the verification, it is not sufficient to state that the GSFC GEVS requirements will be met. A program philosophy must be included. Examples of program philosophy are:

- All components will be subjected to random vibration
- Random vibration will be performed at the subsystem or section level of assembly rather then at the component level
- All instruments will be subjected to acoustics tests and 3-axis sine and random vibration
- All components will be subjected to EMC tests
- All flight hardware will see 8-thermal-vacuum cycles prior to integration on the spacecraft
- Etc.

4.2.1.2 System Performance Verification Matrix

A System Performance Verification Matrix will be prepared and maintained, to show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, results, report reference numbers, etc. This matrix will be included in the system review data packages showing the current verification status as applicable. (Refer to Chapter 3 of this document).

4.2.1.3 Environmental Test Matrix (ETM)

As an adjunct to the system/environmental verification plan, an environmental test matrix will be prepared that summarizes all tests that will be performed on each component, each subsystem or instrument, and the payload. The purpose is to provide a ready reference to the contents of the test program in order to prevent the deletion of a portion thereof without an alternative means of accomplishing the objectives; All flight hardware, spares and prototypes (when appropriate) will be included in the ETM. The matrix will be prepared in conjunction with the initial environmental verification plan and will be updated as changes occur.

A complementary matrix will be kept showing the tests that have been performed on each component, subsystem, instrument, or payload (or other applicable level of assembly). This should include tests performed on prototypes or engineering units used in the qualification program, and should indicate test results (pass/fail or malfunctions).

4.2.1.4 Environmental Verification Specification

As part of the Instrument Performance Verification Plan, or as a separate document, an environmental verification specification will be prepared that defines the specific environmental parameters that each hardware element is subjected to either by test or analysis in order to demonstrate its ability to meet the mission performance requirements. Such things as payload peculiarities and interaction with the launch vehicle will be taken into account.

4.2.2 Performance Verification Procedures

For each verification test activity conducted at the component, subsystem, and payload levels (or other appropriate levels) of assembly, a verification procedure will be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented.

Test procedures will contain details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, pass/fail criteria, quality control checkpoints, data collection, and reporting requirements. The procedures also will address safety and contamination control provisions. (Refer to Addendum B, Item 5.)

4.2.3 Instrument Performance Verification Reports

After each component, subsystem, etc. verification activity has been completed, a report will be submitted. (Refer to Addendum B, Item 6.) For each analysis activity, the report will describe the degree to which the objectives were accomplished, how well the mathematical model was validated by related test data, and other such significant results. In addition, as-run verification procedures and all test and analysis data will be retained for review.

The Instrument Performance Verification Report should be developed and maintained "real-time" throughout the program summarizing the successful completion of verification activities, and showing that the applicable system performance specifications have been acceptably complied with prior to integration of hardware/software into the next higher level of assembly. (Refer to Addendum B, Item 6.)

At the conclusion of the verification program, a final Instrument Performance Verification Report will be delivered comparing the hardware/software specifications with the final verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem.

4.3 ELECTRICAL FUNCTIONAL TEST REQUIREMENTS

This section describes the required electrical functional and performance tests that will verify instrument operation before, during, and after environmental testing. These tests (along with all other calibrations, functional/performance tests, measurements, demonstrations, alignments [and alignment verifications], end-to-end tests, simulations, etc. that are part of the overall verification program) shall be described in the ETM.

4.3.1 Electrical Interface Tests

Before the integration of a component or subsystem into the next higher hardware assembly, electrical interface tests will be performed to verify that all interface signals are within acceptable limits of applicable performance specifications. Prior to mating with other hardware, electrical harnessing will be tested to verify proper characteristics such as the routing of electrical signals, impedance, isolation, and overall workmanship.

4.3.2 Comprehensive Performance Tests (CPT's)

An appropriate CPT will be conducted at the instrument level. When environmental testing is performed at a given level of assembly, additional comprehensive performance tests will be conducted during the hot and cold extremes of the temperature test or the thermal-vacuum test and at the conclusion of the environmental test sequence as well as at other times prescribed in the verification procedures.

The CPT will be a detailed demonstration that the hardware and software meet their performance requirements within allowable tolerances. The CPT will demonstrate the operation of all redundant circuitry and the satisfactory performance in all operational modes. The initial CPT shall serve as a baseline against which the results of all later CPT's can be readily compared.

At the instrument level, the CPT will demonstrate that, with the application of known stimuli, the instrument will produce the expected responses. At lower levels of assembly, the test will demonstrate that, when provided with appropriate inputs, internal performance is satisfactory and outputs are within acceptable limits.

4.3.3 Limited Performance Tests (LPT's)

LPT's will be performed at the instrument level before, during, and after environmental tests, as appropriate, to demonstrate that the functional capability of the instrument has not been degraded by the environmental tests. The LPT's will also be used when CPT's are not warranted. In those cases, the LPT's will become the baseline tests for performance degradation trending. LPT's will demonstrate that the performance of selected hardware and software functions is within acceptable limits. The specific times when LPT's will be performed will be prescribed in the ETM.

4.3.4 Aliveness Tests

An aliveness test will be performed to verify that the instrument and its major components are functioning and that changes or degradation have not occurred as a result of environmental exposure, handling, transportation, or faulty installation. An aliveness test will be performed after major environmental tests, handling, and transportation of the instrument. It will be significantly shorter in duration than a CPT or LPT. Specific times when aliveness tests will be performed will be described in the ETM.

4.3.5 Performance Operating Time and Failure-Free Performance Testing

At the conclusion of the performance verification program, the instrument will have demonstrated failure-free performance testing for at least the last 500 hours of operation. The demonstration may include operating time at the instrument subsystem level of assembly when instrument testing provides insufficient test time to accumulate the trouble-free-operation, or when integration is accomplished at the launch site and the 500 hour demonstration can not practicably be accomplished at the spacecraft level. Failure-free operation during the thermal-vacuum test exposure will be included as part of the demonstration of the trouble-free operation being logged at the hot-dwell and cold-dwell temperatures. Major hardware changes during or after the verification program will invalidate any previous demonstration.

4.3.6 Testing of Limited-Life Electrical Elements

A life test program will be considered for electrical elements that have limited lifetimes as identified in the Limited-Life Items List. The ETM shall address the life test program, identifying the electrical elements that require such testing, describing the test hardware that will be used and the test methods that will be employed. (Refer to Sections 4.4.5.2 and 8.4 of this document.)

4.4 STRUCTURAL AND MECHANICAL REQUIREMENTS

The developer will demonstrate compliance with structural and mechanical requirements through a series of interdependent test and analysis activities. These demonstrations will verify design and specified factors of safety as well as ensure spacecraft interface compatibility, acceptable workmanship, and material integrity. The developer will ensure through discussions/reviews with their own safety engineer and the GSFC GLAST Project Safety Manager that, when it is appropriate, activities needed to satisfy the safety requirements are accomplished in conjunction with these demonstrations.

When planning the tests and analyses, the developer will consider all expected environments including those of structural loads, vibroacoustics, mechanical shock, and pressure profiles. Mass properties and mechanical functioning shall also be verified.

The program outlined in Sections 4.4.1 through 4.4.6 assumes that the design of the instrument is sufficiently modularized to permit realistic environmental exposures at the subsystem level. The developer will ensure that each subsystem of the instrument is verified for each of the requirements identified. In some cases, it may be desirable to satisfy the requirements by test at the component level of assembly in lieu of testing at the subsystem level.

It is the developer's responsibility to document a meaningful set of activities that best demonstrates compliance with the requirements.

4.4.1 Structural Loads

Verification for the structural loads environment will be accomplished through a combination of test and analysis. A modal survey will be performed at the instrument level to verify that the analytic model adequately represents the hardware's dynamic characteristics. The test-verified model will then be used to predict the maximum expected load for each potentially critical loading condition including handling, transportation, and vibroacoustic effects during lift-off. The maximum loads resulting from the analysis will define the limit loads.

Verification of the design strength of the hardware will be accomplished as indicated in the Science Instrument - Spacecraft Interface Requirements Document (SI-SC IRD). When appropriate, development tests can be performed to verify the accuracy of the stress model and (unusually) stringent quality control procedures can be invoked to ensure the conformance of the structure to the design so that strength verification may be accomplished without test by means of a stress analysis in accordance with SI-SC IRD.

The use of materials that are susceptible to brittle fracture or stress-corrosion cracking require the definition of, and strict adherence to, additional appropriate procedures to prevent problems; however, no activity/procedure can override the fact that it is mandatory that all structural elements are in compliance with applicable safety requirements.

4.4.2 Vibroacoustics

To satisfy vibroacoustic requirements, a design verification test program, that is based on an assessment of the expected mission environments and is in accordance with SI-SC IRD, will be developed.

4.4.3 Sinusoidal Sweep Vibration Verification

In accordance with the requirements of SI-SC IRD, the instrument will be subjected to sine sweep vibration to verify its ability to survive the low frequency launch environment. The test will also act as a workmanship test for hardware (e.g., wiring harnesses and stowed appendages) which normally does not respond significantly to the vibroacoustic environment at frequencies below 100 Hz but can experience significant responses from low frequency sine transient vibration and any sustained pogo-like sine vibration. The sine sweep test will be performed at the observatory level.

4.4.4 Mechanical Shock

Both self-induced and externally induced shocks will be considered in defining the mechanical shock environment. All subsystems will be exposed to all self-induced shocks by actuation of the shock-producing devices in accordance with SI-SC IRD. With GSFC's prior permission, the developer may delete the mechanical shock test at the instrument level through verification that it will be handled at the spacecraft level.

4.4.5 Mechanical Function

The instrument's required mechanical function testing is described in Sections 4.4.5.1 though 4.4.5.3.

4.4.5.1 Design Verification

The developer will perform a kinematics analysis of all instrument mechanical operations in accordance with SI-SC IRD to ensure that:

a. Each mechanism can perform satisfactorily and has adequate margins under worst-case conditions

b. Satisfactory clearances exist for both the stowed and operational configurations as well as during any mechanical operation

c. All mechanical elements are capable of withstanding the worst-case loads that may be encountered

Instrument verification tests will be required to demonstrate that the installation of each mechanical device is correct and that no problems exist that will prevent the proper operation of the mechanism throughout the mission.

4.4.5.2 Life Testing

A life test program will be implemented for mechanical and electromechanical devices (e.g., compensators and scanners) that move repetitively as part of their normal function and whose useful life must be determined to verify their adequacy for the mission. The developer will identify such limited life items and their life testing in the ETM. (Refer to Sections 4.3.6 and 8.4 of this document.) The developer will also perform and report trend analysis for these items.

For limited life items for which life-testing will not be performed, the rationale for eliminating the test will be provided to GSFC along with a description of the analyses that will be completed to verify the validity of the rationale. Those analyses will be made available to GSFC for review upon request.

4.4.5.3 Torque Ratio

The developer shall demonstrate through testing or analysis that the instrument hardware meets the torque ratio requirements are defined in the SI-SC IRD.

4.4.6 Mass Properties

The mass properties program will include an analytic assessment of the instrument's ability to comply with the mission requirements, including constraints imposed by the launch vehicle, supplemented as necessary by measurement. The Mass Properties Report shall be prepared and submitted to GSFC in accordance with the CDRL. During the instrument development, data will be reported in the monthly project reports and discussed at quarterly and design reviews. In addition, a comprehensive alignment program shall be executed in conjunction with this program.

4.5 ELECTROMAGNETIC COMPATIBILITY (EMC) REQUIREMENTS

The electromagnetic characteristics of hardware will be designed in accordance with the requirements of SI-SC IRD so that:

a. The instrument and its elements do not generate electromagnetic interference that could adversely affect its own subsystems and components, other instruments, the spacecraft, or the safety and operation of the launch vehicle or the launch site

b. The instrument and its subsystems and components are not susceptible to emissions that could adversely affect their safety and performance. This applies whether the emissions are self-generated or derived from other sources or whether they are intentional or unintentional.

4.6 VACUUM, THERMAL, AND HUMIDITY REQUIREMENTS

Using equipment and/or areas with controlled environments, the developer will conduct a set of tests and analyses that collectively demonstrate the instrument hardware's compliance with the vacuum, thermal, and humidity requirements defined in the SI-SC IRD and Sections 4.6.1 through 4.6.3. Tests may require supporting analyses and vice versa. The developer's program will demonstrate that:

a. The instrument will perform satisfactorily in the vacuum and thermal environment of space

b. The instrument's thermal design and the thermal control system will maintain the affected hardware within the established mission thermal limits

c. The instrument hardware will withstand, as necessary, the temperature and humidity conditions of transportation, storage, and ELV launch

4.6.1 Thermal-Vacuum

The thermal-vacuum test will demonstrate the ability of the instrument to perform satisfactorily in functional modes representative of the mission in vacuum at the nominal mission operating temperatures, at temperatures 10^{o}C beyond the predicted mission extremes, and during temperature transitions. The test will also demonstrate the ability of the instrument to perform satisfactorily after being exposed to the predicted nonfunctional extremes of the mission including the 10^{o}C margin. When applicable, cold and hot turn-ons will be demonstrated.

Prior to its delivery to the Government/spacecraft integrator, the instrument will be subjected to a minimum of eight (8) thermal-vacuum temperature cycles, at least four (4) of which will be at the instrument level. (The remaining cycles may be at lower levels of assembly.) During any thermal-vacuum cycling, the rate of temperature change will not exceed 20^{o}C per hour and soak times at temperature extremes will not start until equilibrium is reached. Where "equilibrium" is defined as the condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified tolerance for the necessary duration. For the purpose of this document, this is defined as a change of not more than 0.5°C for readings once per hour for three hours with a decreasing temperature versus time slope.

For the instrument level tests, the instrument will be subjected to a minimum of four (4) thermal-vacuum temperature cycles, during which the instrument will be soaked for a minimum of sixteen (16) hours at each temperature extreme of each cycle. The developer shall state in the ETM, the proposed testing scenario for the instrument and its components. Throughout the test, the hardware will be operated at all levels of assembly and its performance will be monitored. Instrument turn-on capability will be demonstrated at least twice during the low and high temperature extremes. The instrument's ability to function through the voltage breakdown region will be demonstrated, if applicable. Figure 4-1 illustrates the anticipated thermal-vacuum profile.

Temperature excursions during the cycling of components will be sufficiently large to detect latent defects in workmanship. For components that are determined by analysis to be insensitive to vacuum effects relative to temperature levels and temperature gradients, the gradient may be satisfied by temperature cycling at normal room pressure in an air or gaseous nitrogen environment. However, additional margin and cycles are required if air temperature is employed.

As a part of observatory testing, the instrument hardware will be subjected to a minimum of four (4) additional thermal-vacuum temperature cycles.

4.6.2 Thermal Balance

The validity of the thermal design and the ability/capability of the thermal control system to maintain the hardware within the thermal limits for the mission, as defined in SI-SC IRD and the Statement of Work, will be demonstrated through testing. If the flight hardware is not used in the test of the thermal control system, verification of critical thermal properties (e.g., those of the thermal control coatings) will be performed to demonstrate similarity between the item tested and the flight hardware.

4.6.3 Transportation and Storage Temperature-Humidity Environment

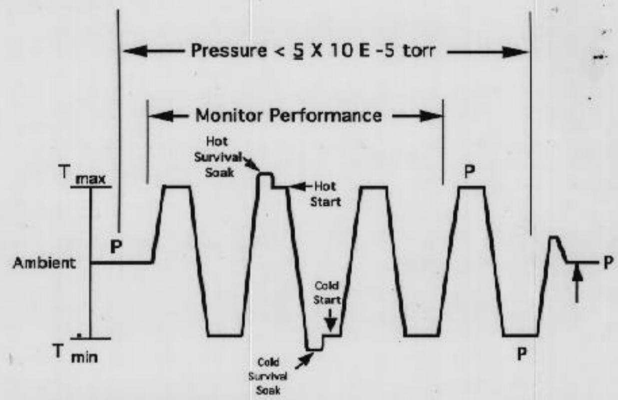
Analyses and, when necessary, tests will be employed to demonstrate that flight hardware that is not maintained in a controlled temperature-humidity environment to within demonstrated acceptable limits and that it will perform satisfactorily after or, if so required, during exposure to an uncontrolled environment. The test will include exposure of the hardware to extremes of temperature and humidity that are 10^{o}C and 10% relative humidity (RH) higher and lower than those predicted for the transportation and storage environments. The exposure at each extreme will be for six (6) hours; however, care will be taken that the RH does not exceed 90%.

4.7 SPACECRAFT/PAYLOAD VERIFICATION DOCUMENTATION

The documentation requirements of section 4.2 also apply to the spacecraft/payload. Following integration of the instruments onto the spacecraft, the spacecraft System Verification Report will include the instrument information.

FIGURE 4-1
THERMAL/VACUUM TEST PROFILE

THERMAL/VACUUM TEST PROFILE



P = Full Functional Performance Testing

Notes for Profile:

A. Maintain plateaus for 16 hours minimum.

B. Maximum rate of change between plateaus shall be nominally +/- 20°C/hour unless specified otherwise in the component test plan.

C. Limited performance testing should be run during transitions.

CHAPTER 5. Electronic Packaging and Processes Requirements

5.0 OVERVIEW OF CHAPTER 5

Chapter 5 addresses the Electronic Packaging and Processes Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) and reference items (RD's) related to this chapter are:

Item	Addendum B Item No./RD No.	MAR Reference Sections	Notes
PWB Coupon Evaluation	Item 7	5.2	
Technology Validation Assessment Plans (TVAP's)	RD 5-1	5.3	

5.1 GENERAL

The developer will plan and implement an Electronic Packaging and Processes Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability.

5.2 WORKMANSHIP

The developer will use the NASA preferred standards identified in the NASA technical standards program in the NASA Online Directives Information System (NODIS). See http://standards.nasa.gov/esscdraft.htm.

Alternate workmanship standards may be used when approved by the project.. The developer will submit, for review and acceptance, the alternate standard and the differences between the alternate standard and the required standard prior to project approval.

The developer will provide printed wiring board coupons and associated test reports in accordance with the contract delivery requirements. Coupons and test reports are not required for delivery to the GSFC Project Office if the developer has coupons evaluated by a laboratory which has been approved by the GSFC Project Office, in writing before the coupons are released for evaluation. (Refer to Addendum B, Item 7.)

5.3 NEW/ADVANCED PACKAGING TECHNOLOGIES

New and/or advanced packaging technologies (e.g., MCM's, stacked memories, chip on board) that have not previously been used in space flight applications will be reviewed and approved through the Parts Control Board (PCB) as defined in Section 6.2. When appropriate, a detailed Technology Validation Assessment Plan (TVAP) may be developed for each new technology. A TVAP identifies the evaluations and data necessary for acceptance of the new/advanced technology for reliable use and conformance to project requirements. (Refer to Chapter 15, RD 5-1.)

New/advanced technologies will be part of the Parts Identification List (PIL) and Project Approved Parts List (PAPL) defined in Section 6.3 of this document.

CHAPTER 6 Parts Requirements

6.0 OVERVIEW OF CHAPTER 6

Chapter 6 addresses the Parts Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) related to this chapter are:

Item	DID No.	MAR Reference Sections	Notes
EEE Parts Control Program	308	6.1	This Plan may be incorporated into the developer's Performance Assurance Implementation Plan
PCB Operating Procedure	308	6.2.1	Incorporate into DID 308.
Developer DPA Plans	308	6.2.6	Incorporate into DID 308.
PCB Reports (or Parts and Materials Control Board [PMCB] Reports)	309	6.2.1.1, 7.1.1	
Paarts Identification List (PIL)	310	6.3, 6.3.2	As-designed and as-built parts lists.
Alert/Advisory Disposition & Preparation	311	6.4	

6.1 GENERAL

The developer will plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability. (Refer to the CDRL, DID 308.)

The developer will prepare a Parts Control Plan (PCP) describing the approach and methodology for implementing the Parts Control Program. The PCP will also define the developer's criteria for parts selection and approval based on the guidelines of this section. The PCP may be incorporated into the developer's Performance Assurance Implementation Plan. (Refer to the CDRL, DID 301.)

6.2 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS

All part commodities identified in the NASA Parts Selection List are considered EEE parts and will be subjected to the requirements set forth in this section. Custom or advanced technology devices such as custom hybrid microcircuits, detectors, Application Specific Integrated Circuits (ASIC), Multi-Chip Modules (MCM), and magnetics will also be subject to parts control appropriate for the individual technology. (See Section 6.2.2.1 of this document.)

6.2.1 Parts Control Board

The developer will establish a Parts Control Board (PCB) or a similar documented system to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. (The developer may elect to establish a Parts and Materials Control Board or PMCB.) The PCB will be responsible for the review and approval of all parts for conformance to established criteria, and for developing and maintaining a Project Approved Parts List (PAPL). In addition, the PCB will be responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. PCB operating procedures will be included as part of the PCP.

6.2.1.1 PCB Meetings

PCB meetings will be convened as necessary to evaluate acceptance of EEE parts and/or materials in a timely manner to support the GLAST Project schedule. Meetings will be held prior to the procurement of parts and/or materials. At a minimum, the PCB meetings will be convened prior to the PDR to determine the acceptability of EEE parts including those proposed for use by both the contractor and/or their subcontractors, vendors, or collaborators. Emergency PCB meetings will be convened at the discretion of the PCB chair via telecon or e-mail to meet Project needs and schedules. The chair will be responsible for the scheduling of PCB meetings and will notify all members, including GSFC, at least 10 working days prior to each (non-emergency) meeting via telephone or e-mail.

GSFC may participate in PCB meetings and will be notified in advance of all upcoming meetings. If participating, GSFC will have voting rights at PCB meetings. Meeting minutes or records will be maintained by the developer to document all decisions made and a copy provided to GSFC within three days of convening the meeting. (Refer to the CDRL, DID 309.) GSFC will retain the right to overturn decisions involving non-conformances within ten days after receipt of meeting minutes. PCB activities may be audited by GSFC on a periodic basis to assess conformance to the developer's PCP.

6.2.2 Parts Selection and Processing

All parts will be selected and processed in accordance with the GSFC 311-INST-001 Instructions for EEE Parts Selection, Screening and Qualification. All application notes in 311-INST-001 will apply. The appropriate parts quality level defined in 311-INST-001 will be based on system redundancy or criticality as determined by the Project Manager. The requirements of 311-INST-001 may be further tailored as appropriate to specific missions. Developer's internal selection and processing documentation may be used to define these requirements. The requirements will then become the established criteria for parts selection, testing, and approval for the duration of the project, and will be documented in the PCP. Parts selected from the NASA Parts Selection List, MIL-STD-975, (see http://misspiggy.gsfc.nasa.gov) and the GSFC Preferred Parts List (PPL) are considered to have met all criteria of 311-INST-001 for the appropriate parts quality level and may be approved by the PCB provided all mission application requirements (performance, derating, radiation, etc.) are met.

6.2.2.1 Custom Devices

In addition to applicable requirements of 311-INST-001, custom microcircuits, hybrid microcircuits, MCM, ASIC, magnetics, etc. planned for use by the developer will be subjected to a design review. The review may be conducted as part of the PCB activity. The design review will address, at a minimum, derating of elements, method used to assure each element reliability, assembly process and materials, and method for assuring adequate thermal matching of materials.

6.2.3 Derating

All EEE parts will be used in accordance with the derating guidelines of the NASA Parts Selection List. (See http://misspiggy.gsfc.nasa.gov.) The developer's derating policy may be used in place of the NASA Parts Selection List guidelines and will be submitted with the PCP. The developer will maintain documentation on parts derating analysis and will make it available for GSFC review.

6.2.4 Radiation Hardness

All parts will be selected to meet their intended application in the predicted mission radiation environment. The radiation environment consists of two separate effects, those of total ionizing dose and single-event effects. The developer will document the analysis for each part with respect to both effects.

6.2.5 Verification Testing

Verification of screening or qualification tests by re-testing is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. If required, testing will be in accordance with 311-INST-001 as determined by the PCB. The developer, however, will be responsible for the performance of supplier audits, surveys, source inspections, witnessing of tests, and/or data review to verify conformance to established requirements.

6.2.6 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrid microcircuits, and semiconductor devices will be subjected to a Destructive Physical Analysis (DPA). All other parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. DPA tests, procedures, sample size, and criteria will be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. Developer's procedures for DPA may be used in place of S-311-M-70 and will be submitted with the PCP. Variation to the DPA sample size requirements, due to part complexity, availability, or cost, will be determined and approved by the PCB on a case-by-case basis. In lieu of performing the required DPA's, the developer may provide the required number of DPA samples to GSFC for DPA. This will be accomplished on a case by case basis through mutual agreement by the developer and GSFC.

6.2.7 Failure Analysis

Failure analyses, performed by experienced personnel, will be required to support the non conformance reporting system. The (in-house or out-of-house) failure analysis laboratory shall be equipped to analyze parts to the extent necessary to ensure an understanding of the failure mode and cause. The failure analyses shall be available to GSFC for review upon request.

6.2.8 Parts Age Control

Parts drawn from controlled storage after 5 years from the date of the last full screen will be subjected to a full 100 percent re-screen and sample DPA. Alternative test plans may be used as determined and approved by the PCB on a case-by case basis. Parts over 10 years from the date of the last full screen or stored in other than controlled conditions where they are exposed to the elements or sources of contamination will not be used.

6.3 PARTS LISTS

The developer will create and maintain a Project Approved Parts List (PAPL) and a Parts Identification List (PIL) for the duration of the project. The developer may choose to incorporate the PAPL and PIL into one list, which will be submitted to GSFC as a PIL, provided clear distinctions are made as to parts approval status and whether parts are planned for use in flight hardware. (Refer to the CDRL, DID 310.)

6.3.1 Project Approved Parts List

The Project Approved Parts List (PAPL) will be the only source of approved parts for project flight hardware, and as such may contain parts not actually in flight design. Only parts that have been evaluated and approved by the PCB will be listed in the PAPL. Parts must be approved for listing on the PAPL before initiation of procurement activity. The criteria for PAPL listing will be based on 311-INST-001 and as specified herein. (See Section 6.2.2.) The PCB will assure standardization and the maximum use of parts listed in the PAPL. The PAPL and all subsequent revisions will be available for GSFC review upon request.

6.3.1.1 Parts Approved on Prior Projects

Parts previously approved by GSFC via the developer's Nonstandard Parts Approval Request (NSPAR) on a preceding contract for a system similar to the one being procured will be evaluated by the PCB for continued compliance to current project requirements prior to listing in the PAPL. This will be accomplished by determining that:

a. No changes have been made to the previously approved NSPAR, Source Control Drawing (SCD), or vendor list.

b. All stipulations cited in the previous NSPAR approval have been implemented on the current flight lot including performance of any additional testing.

c. The previous project's parts quality level is identical to the current project.

6.3.2 Parts Identification List

As opposed to the PAPL, the Parts Identification List (PIL) will list all parts planned for use in flight hardware regardless of their approval status. The initial PIL and subsequent updates will be submitted to GSFC in accordance with the contract delivery requirements. An As-Built Parts List (ABPL) will also be prepared and submitted to GSFC in accordance with the contract delivery requirements. The ABPL is generally the final PIL with additional as-built information, such as parts manufacturers and lot date code. (Refer to the CDRL, DID 310.)

6.4 ALERTS

The developer will be responsible for the review and disposition of Government Industry Data Exchange Program (GIDEP) Alerts for applicability to the parts proposed for use or incorporated into the design. In addition, any NASA Alerts and Advisories provided to the developer by GSFC will be reviewed and dispositioned. Alert applicability, impact, and corrective actions will be documented and reported, upon request, to the GSFC Project Office. Additionally, when appropriate, the developer will prepare, or assist GSFC personnel in preparing, Alerts. (Refer to the CDRL, DID 311.)

CHAPTER 7. Materials, Processes, and Lubrication Requirements

7.0 OVERVIEW OF CHAPTER 7

Chapter 7 addresses the Materials, Processes, and Lubrication Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) and reference items (RD's) related to this chapter are:

Item	DID/RD No.	MAR Reference Sections	Notes
Materials and Processes Plan	DID 312	7.1	May be incorporated in the developer's Performance Assurance Implementation Plan
Material Usage Agreements	DID 313	7.2.1, 7.2.2, 7.2.2.1, 7.2.5.2, 7.2.6	
Stress Corrosion Evaluation Form	RD 7-1	7.2.2, 7.2.6	
Non-conventional Material and Lubrication Report	RD 7-2	7.2.4	
Polymeric Materials and Composites Usage List	DID 314	7.2.5	
Material Waiver	RD 7-3	7.2.5.3	For Shelf-Life-Controlled Materials
Limited Life Plan for Lubricated Mechanisms	RD 7-4	7.2.5.3, 7.2.7 and 7.4	
Inorganic Materials and Composites Usage List	DID 315	7.2.6	
Material Test Report for Fastener Lots	RD 7-5	7.2.6.1	
Fastener Control Plan	RD 7-6	7.2.6.1	
Lubrication Usage List	DID 316	7.2.7	
Material Process Utilization List	DID 317	7.3	
Certificate of Raw Material Compliance	RD 7-7	7.4.1, 7.4.2	

7.1 GENERAL REQUIREMENTS

The developer will implement a comprehensive Materials and Processes Plan (Refer to the CDRL, DID 312.) beginning at the design stage of the hardware. The Materials and Processes Plan (M&PP) will help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials and lubricants employed to meet the operational requirements for the instrument. Materials and lubrication assurance approval is required for each usage or application in space-flight hardware. The M&PP may be incorporated in the developer's Performance Assurance Implementation Plan. (Refer to the CDRL, DID 301.)

7.1.1 Parts and Material Control Board

The M&PP may call for a Parts and Materials Control Board (PMCB). If so, the PMCB reports will be submitted to GSFC in accordance with Chapter 15, DID 6-2.

7.2 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer will, when selecting materials and lubricants, consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxic offgassing, flammability and fracture toughness as well as the properties required by each material usage or application.

7.2.1 Compliant Materials

The developer will use compliant materials in the fabrication of flight hardware to the extent practicable.

In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria identified in Table 7.1. A compliant material does not require a Materials Usage Agreement (MUA). (Refer to the CDRL, DID 313.)

TABLE 7-1
MATERIAL SELECTION CRITERIA

Type Launch	Payload Location	Flammability and Toxic Offgassing	Vacuum Outgassing	Stress Corrosion Cracking (SCC)
ELV	All	Note 1	Note 2	Note 3

NOTES:

1. Hazardous materials requirements, including flammability, toxicity and compatibility as specified in Eastern and Western Range 127-1 Range Safety Requirements, Sections 2.10 and 2.12.

2. Vacuum Outgassing requirements as defined in Section 7.2.5.2.

3. Stress corrosion cracking requirements as defined in MSFC-SPEC-522.

7.2.2 Non-compliant Materials

A material that does not meet the requirements of the applicable selection criteria of Table 7.1 or meet the requirements of Table 7.1, but is used in an unconventional application, will be considered to be a non-compliant material. The proposed use of a non-compliant material requires that a Materials Usage Agreement (MUA). In addition to the MUA, or as replacement for the MUA, GSFC and the developer may mutually agree on the use of a Stress Corrosion Evaluation Form or developer's equivalent forms as a means for the developer to relay information that is needed for material approval to the Government. (Refer to the CDRL, DID 313 and Chapter 15, RD 7-1.) Refer to Figure 7-1 and Figure 7-2 below.

7.2.2.1 Materials Used in "Off-the-Shelf-Hardware"

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed will be treated as non-compliant. The developer will define on a MUA (DID 313), what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one or a combination of the following: hermetic sealing, vacuum bake-out, material changes for known non-compliant materials, etc. When a vacuum bake-out is the selected method, it must incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bake-out as well as compliance with the satellite contamination plan and error budget.

7.2.3 Conventional Applications

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

7.2.4 Non-conventional Applications

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage will be considered a non-conventional application. Under these circumstances, GSFC and the developer may agree for the developer to provide any/all the information required in a Non-conventional Material and Lubrication Report so that the Government may fully understand the application.

(Refer to Chapter 15, RD 7-2.) In that case, the material usage will be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods.

7.2.5 Polymeric Materials

The developer will prepare and submit a polymeric materials and composites usage list or the developer's equivalent. (Refer to the CDRL, DID 314.) Refer to Figure 7-3. The list will be submitted to GSFC for review/approval. Material acceptability will be determined on the basis of flammability, toxic offgassing, vacuum outgassing, and all other materials properties relative to the application requirements and usage environment.

7.2.5.1 Flammability and Toxic Offgassing

Material flammability and toxic offgassing will be determined in accordance with the test methods described in NASA-STD-6001. Expendable launch vehicle (ELV) payload materials will meet the requirements of Eastern and Western Range 127-1 Range Safety Requirements, Sections 2.10 and 2.12.

7.2.5.2 Vacuum Outgassing

Material vacuum outgassing will be determined in accordance with ASTM E-595. In general, a material is qualified on a product-by-product basis. However, GSFC may require lot testing of any material for which lot variation is suspected. In such cases, material approval is contingent upon lot testing. Only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% will be approved for use in a vacuum environment unless application considerations listed on a MUA (DID 313) dictate otherwise. (The overall mission contamination control requirements may demand more stringent outgassing criteria.

7.2.5.3 Shelf-Life-Controlled Materials

Polymeric materials that have a limited shelf-life will be controlled by a process that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf-life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints will be included. The use of materials whose date code has expired requires that the developer demonstrate, by means of appropriate tests, that the properties of the materials have not been compromised for their intended use. Such materials must be approved by GSFC. This may be accomplished by means of a waiver. (Refer to Chapter 15, RD 7-3.) When a limited-life piece part is installed in a subassembly, its usage must be approved by GSFC. This may be accomplished by including the subassembly item in the Limited-Life Plan. (Refer to Chapter 15, RD 7-4.)

7.2.6 Inorganic Materials

The developer will prepare and document an inorganic materials and composites usage list (Figure 7.4) or the developer's equivalent. (Refer to the CDRL, DID 315) The list will be submitted to GSFC for review and approval. In addition, the developer may be requested to submit supporting applications data. The criteria specified in MSFC-SPEC-522 will be used to determine that metallic materials meet the stress corrosion cracking criteria. An MUA (DID 313) will be submitted for each material usage that does not comply with the MSFC 522 SCC requirements. Additionally, for the Government to approve usage of individual materials, a stress corrosion evaluation form (RD 7-1), as discussed in Section 7.2.2, or an equivalent developer form or any/all of the information contained in the stress corrosion evaluation form may be required by GSFC from the developer. Nondestructive evaluation requirements are contained in the ELV structure integrity requirements.

7.2.6.1 Fasteners

As part of the parts and materials list approval process, the Government will approve all flight fasteners. Towards this end, the developer shall provide all information required by the Government to ensure its ability to concur with the flightworthiness of LAT flight fasteners.

For ELV launched payloads, the developer will comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC S-313-100, Goddard Space Flight Center Fastener Integrity

Requirements. To document this process, it is recommended that the developer prepare a Fastener Control Plan for submission to GSFC. (Refer to Chapter 15, RD 7-6.) Additionally, it is recommended that material test reports for fastener lots are submitted to GSFC for information. (Refer to Chapter 15, RD 7-5.)

Fasteners made of plain carbon or low alloy steel will be protected from corrosion. When plating is specified, it will be compatible with the space environment. On steels harder than RC 33, plating will be applied by a process that is not embrittling to the steel.

7.2.7 Lubrication

<table>
<tr><td colspan="3">MATERIAL USAGE AGREEMENT</td><td colspan="5">USAGE AGREEMENT NO.:</td><td>PAGE OF</td></tr>
<tr><td>PROJECT:</td><td colspan="2">SUBSYSTEM:</td><td colspan="5">ORIGINATOR:</td><td>ORGANIZATION:</td></tr>
<tr><td>DETAIL DRAWING</td><td colspan="3">NOMENCLATURE</td><td colspan="3">USING ASSEMBLY</td><td colspan="2">NOMENCLATURE</td></tr>
<tr><td></td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="4">MATERIAL & SPECIFICATION</td><td colspan="5">MANUFACTURER & TRADE NAME</td></tr>
<tr><td colspan="4"></td><td colspan="5"></td></tr>
<tr><td rowspan="2">USAGE</td><td rowspan="2">THICKNESS</td><td rowspan="2">WEIGHT</td><td rowspan="2">EXPOSED AREA</td><td colspan="5">ENVIRONMENT</td></tr>
<tr><td>PRESSURE</td><td colspan="3">TEMPERATURE</td><td>MEDIA</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3"></td><td></td></tr>
<tr><td colspan="9">APPLICATION:</td></tr>
<tr><td colspan="9">RATIONALE:</td></tr>
<tr><td colspan="4">ORIGINATOR:</td><td colspan="4">PROJECT MANAGER:</td><td>DATE:</td></tr>
</table>

FIGURE 7-1 MUA

STRESS CORROSION EVALUATION FORM

1. Part Number ______________________________________
2. Part Name ____
3. Next Assembly Number _____________________________
4. Manufacturer _____________________________________
5. Material ____
6. Heat Treatment ___________________________________
7. Size and Form ____________________________________
8. Sustained Tensile Stresses-Magnitude and Direction

a. Process Residual __________________________________

b. Assembly ____

c. Design, Static ____________________________________

9. Special Processing _________________________________
10. Weldments

a. Alloy Form, Temper of Parent Metal ____________________

b. Filler Alloy, if none, indicate ________________________

c. Welding Process ___________________________________

d. Weld Bead Removed - Yes ( ), No ( ) ___________________

e. Post-Weld Thermal Treatment _________________________

f. Post-Weld Stress Relief ______________________________

11. Environment ______________________________________
12. Protective Finish ___________________________________
13. Function of Part ___________________________________

    ____
14. Effect of Failure ___________________________________

    ____
15. Evaluation of Stress Corrosion Susceptibility ______________

    ____
16. Remarks: ____

    ____

Figure 7-2 Stress Corrosion Evaluation Form

The developer will prepare and document a lubrication usage list (Figure 7.5) or the developer's equivalent. (Refer to the CDRL, DID 316.) The list will be submitted to GSFC for approval. The developer may be requested to submit supporting applications data.

Lubricants will be selected for use with materials on the basis of valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects.

All lubricated mechanisms will be qualified by life testing (RD 7-4) or heritage of an identical mechanism used in identical applications. In either circumstance, evidence of qualification must be provided to the Government.

7.3 PROCESS SELECTION REQUIREMENTS

The developer will prepare and document a material process utilization list or the developer's equivalent (Figure 7.5). (Refer to the CDRL, DID 317.) The list will be submitted to GSFC for review/approval. A copy of any process will be submitted for review upon request. Manufacturing processes (e.g., lubrication, heat treatment, welding, and chemical or metallic coatings) will be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

7.4 PROCUREMENT REQUIREMENTS

7.4.1 Purchased Raw Materials

Raw materials purchased by the developer will be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance. This information need only be provided to the Government when there is a direct question concerning the material's flightworthiness. (Refer to Chapter 15, RD 7-7.)

7.4.2 Raw Materials Used in Purchased Products

The developer will require that their suppliers meet the requirements of Section 7.4.1 of this document and provide, upon request, the results of acceptance tests and analyses performed on raw materials (RD 7-7).

POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ____________________ SYSTEM/EXPERIMENT____________________ GSFC T/O ____________________

DEVELOPER/CONTRACTOR____________________ ADDRESS____________________

PREPARED BY ____________________ PHONE____________________ DATE PREPARED____________________

GSFC MATERIALS EVALUATOR____________________ PHONE____________________ DATE RECEIVED ____________________ DATE EVALUATED ____________________

Area, cm^2	Vol., cc	Wt., gm
1 0-1	A 0-1	a 0-1
2 2-100	B 2-50	b 2-50
3 101-1000	C 51-500	c 51-500
4 >1000	D >500	d >500

ITEM NO.	MATERIAL IDENTIFICATION(2)	MIX FORMULA(3)	CURE(4)	AMOUNT CODE	EXPECTED ENVIRONMENT(5)	REASON FOR SELECTION(6)	OUTGASSING VALUES	
							TML	CVCM

NOTES

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list.

2. Give the name of the material, identifying number and manufacturer. Example: Epoxy, Epon 828, E. V. Roberts and Associates

3. Provide proportions and name of resin, hardener (catalyst), filler, etc. Example: 828/V140/Silflake 135 as 5/5/38 by weight

4. Provide cure cycle details. Example: 8 hrs. at room temperature + 2 hrs. at 150C

5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group. Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen

6. Provide any special reason why the materials was selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

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FIGURE 7-3 POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

INORGANIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ______ SYSTEM/EXPERIMENT______ GSFC T/O ______
DEVELOPER/CONTRACTOR______ ADDRESS______
PREPARED BY ______ PHONE______ DATE PREPARED ______
GSFC MATERIALS EVALUATOR______ PHONE______ DATE RECEIVED ______ DATE EVALUATED______

ITEM NO.	MATERIAL IDENTIFICATION(2)	CONDITION(3)	APPLICATION(4) OR OTHER SPEC. NO.	EXPECTED ENVIRONMENT(5)	S.C.C. TABLE NO.	MUA NO.	NDE METHOD

NOTES:

1. List all inorganic materials (metals, ceramics, glasses, liquids, and metal/ceramic composites) except bearing and lubrication materials that should be listed on Form 18-59C.
2. Give materials name, identifying number manufacturer.
   Example: a. Aluminum 6061-T6
   b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc.
   c. Fused silica, Corning 7940, Corning Class Works
3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
   Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed.
   b. Surface coated with vapor deposited aluminum and magnesium fluoride
   c. Cold worked to full hare condition, TIG welded and electroless nickel plated.
4. Give details of where on the spacecraft the material will be used (component) and its function.
   Example: Electronics box structure in attitude control system, not hermetically sealed.
5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
   Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen

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FIGURE 7-4 INORGANIC MATERIALS AND COMPOSITES USAGE LIST

LUBRICATION USAGE LIST

SPACECRAFT ______________________ SYSTEM/EXPERIMENT______________________ GSFC T/O ______________

DEVELOPED/CONTRACTOR______________________ ADDRESS______________________

PREPARED BY ______________________ PHONE______________________ DATE PREPARED ______________

GSFC MATERIALS EVALUATOR______________________ PHONE______________ DATE RECEIVED ______________ DATE EVALUATED______________

ITEM NO.	COMPONENT TYPE, SIZE MATERIAL(1)	COMPONENT MANUFACTURER & MFR. IDENTIFICATION	PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT	TYPE & NO. OF WEAR CYCLES(2)	SPEED, TEMP., ATM. OF OPERATION(3)	TYPE OF LOADS & AMT.	OTHER DETAILS(5)

NOTES

(1) BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts. Give generic identification of materials used for the component, e.g., 440C steel, PTFE.

(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°), CS = continuous sliding, IS = intermittent sliding.
No. of wear cycles: A(1-10^2), B(10^2-10^4), C(10^4-10^6), D($>10^6$)

(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed
CPM = cm/min. (sliding applications)
Temp. of operation, max. & min., °C
Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.

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FIGURE 7-5 LUBRICATION USAGE LIST

MATERIALS PROCESS UTILIZATION LIST

SPACECRAFT ____________________ SYSTEM/EXPERIMENT____________________ GSFC T/O ____________

DEVELOPER/CONTRACTOR____________________ ADDRESS____________________

PREPARED BY ____________________ PHONE____________________ DATE PREPARED ____________

GSFC MATERIALS EVALUATOR____________________ PHONE____________ DATE RECEIVED ____________ DATE EVALUATED ____________

ITEM NO.	PROCESS TYPE[1]	CONTRACTOR SPEC. NO.[2]	MIL., ASTM., FED. OR OTHER SPEC. NO.	DESCRIPTION OF MAT'L PROCESSED[3]	SPACECRAFT/EXP. APPLICATION[4]

NOTES

(1) Give generic name of process, e.g., anodizing (sulfuric acid).

(2) If process if proprietary, please state so.

(3) Identify the type and condition of the material subjected to the process.
E.g., 6061-T6

(4) Identify the component or structure of which the materials are being processed.
E.g., Antenna dish

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FIGURE 7-6 MATERIALS PROCESS UTILIZATION LIST

CHAPTER 8. Reliability Requirements

8.0 OVERVIEW OF CHAPTER 8

Chapter 8 addresses the Reliability Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) and reference items (RD's) related to this chapter are:

Item	DID/RD No./ Addendum B Item No.	MAR Reference Sections	Notes
Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)	DID 318	8.2.1	• The developer is to prepare the lists/ analyses/assessments and retain documentation at their facility for GSFC review/audit. • Results are to be reported at design reviews.
Parts Stress Analyses	Item 8	8.2.2	
Worst Case Analyses	RD 8-1	8.2.3	
Reliability Assessments	RD 8-2	8.2.4	
Trend Analysis	RD 8-3	8.3.1, 8.3.2	
Limited Life List	DID 319	8.4	The developer will prepare and deliver to GSFC

8.1 GENERAL REQUIREMENTS

The developer will plan and implement a reliability program that interacts effectively with other project disciplines, including systems engineering, hardware design, and product assurance. The program will be tailored according to the risk level to:

a. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable.

b. Demonstrate that the stress applied to parts is not excessive.

c. Identify single failure items/points, their effect on the attainment of mission objectives, and possible safety degradation.

d. Show that the reliability design aligns with mission design life and is consistent among the systems, subsystems, and components.

e. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations.

f. Select significant engineering parameters for the performance of trend analysis to identify performance trends during pre-launch activities.

g. Ensure that the design permits easy replacement of parts and components and that redundant paths are easily monitored.

h. Ensure that the LAT meets its reliability allocation as part of the GLAST observatory. (Refer to the GLAST Mission System Specification, GSFC 433-SPEC-0001.)

8.2 RELIABILITY ANALYSES

Reliability analyses will be performed concurrently with the instrument's design so that identified problem areas can be addressed and correction action taken (if required) in a timely manner.

8.2.1 Failure Modes and Effects Analysis and Critical Items List

A Failure Modes and Effects Analysis (FMEA) will be performed early in the design phase to identify system design problems. As additional design information becomes available the FMEA will be refined.

Failure modes will be assessed at the component interface level. Each failure mode will be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode will be assigned a severity category based on the most severe effect caused by a failure. Mission phases (e.g., launch, deployment, on-orbit operation, and retrieval) will be addressed in the analysis.

Severity categories will be determined in accordance with Table 8-1:

Category	Severity Definition
1	Catastrophic Failure modes that could result in serious injury, loss of life (flight or ground personnel), or loss of launch vehicle.
1R	Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1 effects.
1S	Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and lead to Severity Category 1 consequences.
2	Critical Failure modes that could result in loss of one or more mission objectives as defined by the GSFC project office.
2R	Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
3	Significant Failure modes that could cause degradation to mission objectives.
4	Minor Failure modes that could result in insignificant or no loss to mission objectives

TABLE 8-1

SEVERITY CATEGORIES

FMEA analysis procedures and documentation will be performed in accordance with documented procedures. Failure modes resulting in Severity Categories 1, 1R, 1S or 2 will be analyzed at a greater depth, to the single parts if necessary, to identify the cause of failure.

Results of the FMEA will be used to evaluate the design relative to requirements (e.g., no single instrument failure will prevent removal of power from the instrument). Identified discrepancies will be evaluated by management and design groups for assessment of the need for corrective action.

The FMEA will analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path will not affect the other functional path(s) or the capability to switch operation to that redundant path.

All failure modes that are assigned to Severity Categories 1, 1R, 1S, and 2, will be itemized on a Critical Items List (CIL) and maintained with the FMEA report. (Refer to the CDRL, DID 318.) Rationale for retaining the items will be included on the CIL. The FMEA and CIL will be held at the developer's facility for Government review and/or audit. Results of the FMEA as well as the CIL will be presented at all design reviews starting with the PDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

8.2.2 Parts Stress Analyses

Each application of electrical, electronic, and electromechanical (EEE) parts, will be subjected to stress analyses for conformance with the applicable derating guidelines. (Refer to MAR Section 6.2.3.) The analyses will be performed at the most stressful values that result from specified performance and environmental requirements (e.g., temperature and voltage) on the assembly or component. The analyses will be performed in close coordination with the packaging reviews (See MAR Section 3.5.) and thermal analyses and they will be required input data for component-level design reviews. (Refer to MAR Section 3.5.) The analyses with summary sheets and updates will be maintained at the developer's facility for the Government to review/audit. (Refer to Addendum B, Item 8.) The results of the analyses will be presented at all design reviews starting with a preliminary report at the PDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

8.2.3 Worst Case Analyses

Worst Case Analyses will be performed on circuits where failure results in a severity category of 2 or higher question the flightworthiness of the design. The most sensitive design parameters, including those that are subject to variations that could degrade performance, will be subjected to the analysis. The adequacy of design margins in the electronic circuits, optics, electromechanical, and mechanical items will be demonstrated by analyses or test or both to ensure flighworthiness. This analysis (when performed) will be made available at the developer's facilities for GSFC review. (Refer to Chapter 15, RD 8-1.) The results of any analyses will be presented at all design reviews starting with the PDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

The analyses will consider all parameters set at worst case limits and worst case environmental stresses for the parameter or operation being evaluated. Depending on mission parameters and parts selection methods, part parameter values for the analysis will typically include: manufacturing variability, variability due to temperature, aging effects of environment, and variability due to cumulative radiation. The analyses will be updated in keeping with design changes. The analyses and updates will be made available to GSFC for information upon request.

8.2.4 Reliability Assessments

When necessary/prudent or when agreed-upon with the Government, the developer will perform comparative numerical reliability assessments to:

a. Evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions

b. Identify the elements of the design which are the greatest detractors of system reliability

c. Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations

d. Assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable

e. Evaluate the impact of proposed engineering change and waiver requests on reliability

The developer will specify in their PAIP or PAP how reliability assessments will be integrated with the design process and other assurance practices to maximize the probability of meeting mission success criteria. The developer will describe how the reliability assessments will incorporate definitions of failure as well as alternate and degraded operating modes that clearly describe plausible acceptable and unacceptable levels of performance. Degraded operating modes will include failure conditions that could be alleviated or reduced significantly through the implementation of work-arounds via telemetry.

The developer will further describe in their PAIP or PAP the level of detail of a model suitable for performing the intended functions enumerated above. The assessments and updates will be submitted to GSFC for information. (Refer to Chapter 15, RD 8-2.) The results of any reliability assessment will be reported at PDR and CDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

8.3 ANALYSIS OF TEST DATA

The developer will fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

8.3.1 Trend Analyses

As part of the routine system assessment, the developer will assess all subsystems and components to determine measurable parameters that relate to performance stability. Selected parameters will be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring will be accomplished within the normal test framework; i.e., during functional tests, environmental tests, etc. The developer will establish a system for recording and analyzing the parameters as well as any changes from the nominal even if the levels are within specified limits. Trend analysis data will be reviewed with the operational personnel prior to launch, and the operational personnel will continue recording trends throughout mission life. A list of subsystem and components to be assessed and the parameters to be monitored and the trend analysis reports will be maintained. (Refer to Chapter 15, RD 8-3.)

8.3.2 Analysis of Test Results

The developer will analyze test information, trend data, and failure investigations to evaluate reliability implications. Identified problem areas will be documented and directed to the attention of developer management for action. The results of the analyses will be presented at design reviews. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions. (Refer to Chapter 15, RD 8-3.)

8.4 LIMITED-LIFE ITEMS

Limited-life items will be identified and managed by means of a Limited-Life Plan, which will be submitted for approval. (Refer to the CDRL, DID 319.) The plan will present definitions, the impact on mission parameters, responsibilities, and a list of limited-life items, including data elements: expected life, required life, duty cycle, and rationale for selection. The useful life period starts with fabrication and ends with the completion of the final orbital mission.

The list of limited-life items should include selected structures, thermal control surfaces, solar arrays, and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue should be used to identify limited-life thermal control surfaces and structure items. Mechanisms such as batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators, and scan devices should be included when aging, wear, fatigue and lubricant degradation limit their life. Records will be maintained that allow evaluation of the cumulative stress (time and/or cycles) for limited-life items starting when useful life is initiated and indicating the project activity that will stress the items. (Refer to Sections 4.3.6 and 4.4.5.2 of this document.) The use of an item whose expected life is less than its mission design life must be approved by GSFC by means of a program waiver.

CHAPTER 9. Quality Assurance Requirements

9.0 QUALITY MANAGEMENT SYSTEM

Chapter 8 addresses the Quality Management Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project. The developer will have a Quality Management System that meets the minimum requirements of ANSI/ASQC Q9001-l994. The developer's Quality Manual will be provided in accordance with the Contract Schedule. (Refer to the CDRL, DID 320.)

The deliverable items (DID's) related to this chapter are:

Item	DID No.	MAR Reference Sections	Notes
Quality Manual	320	9.0, 11.1	
Nonconformance Reports	321	9.1.3	

9.1 QA MANAGEMENT SYSTEM REQUIREMENTS AUGMENTATION

The following requirements augment the identified portions of ANSI/ASQC Q9001-1994.

9.1.1 Section 4.4.4:

New on-orbit design of software and ground stations hardware shall be in accordance with original system design specifications and validation processes.

9.1.2 Section 4.6.3:

The supplier's QA program should ensure flow-down to all major and critical suppliers of technical requirements and a process to verify compliance.

9.1.3 Section 4.13.2:

The reporting of failures will begin with the first power application at the lowest level of assembly or the first operation of a mechanical item. It will continue through formal acceptance by the GSFC Project Office.

Failures will be reported to the GSFC Project Office. (Refer to the CDRL, DID 321.) The documentation provided to GSFC will include Material Review Board (MRB) and Failure Review Board (FRB) minutes and reports.

Developer review/disposition/approval of failure reports will be described in the applicable procedure(s) which are included, or referenced to, in the Quality Manual.

CHAPTER 10. Contamination Control Requirements

10.0 OVERVIEW OF CHAPTER 10

Chapter 10 addresses the Contamination Control Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable item (DID) related to this chapter is:

Item	DID No.	MAR Reference Sections	Notes
Contamination Control Plan (CCP)	322	10.1, 10.2	This Plan may be incorporated into the developer's PAIP.

10.1 GENERAL

The developer will plan and implement a contamination control program applicable to the hardware. The program will establish the specific cleanliness requirements and delineate the approaches in a Contamination Control Plan (CCP). (Refer to the CDRL, DID 322.) This plan may be incorporated into the PAIP. (Refer to the CDRL, DID 301.)

10.2 CONTAMINATION CONTROL PLAN

The developer will prepare a CCP that describes the procedures that will be followed to control contamination. The CCP will define a contamination allowance for performance degradation of contamination sensitive hardware such that, even in the degraded state, the hardware will meet its mission objectives. The CCP will establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the hardware's lifetime. In general, all mission hardware should be compatible with the most contamination-sensitive components.

10.3 MATERIAL OUTGASSING

All materials will be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data will be established based on hardware's operating conditions and reviewed by GSFC.

10.4 THERMAL VACUUM BAKEOUT

The developer will perform thermal vacuum bakeouts of all hardware. The parameters of such bakeouts (e.g., temperature, duration, and pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance.

10.5 HARDWARE HANDLING

The developer will practice cleanroom standards in handling hardware. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging will be addressed.

CHAPTER 11. Software Assurance Requirements

11.0 OVERVIEW OF CHAPTER 11

Chapter 11 addresses the Software Assurance Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) and reference items (RD's) related to this chapter are:

Items	DID/RD No.	MAR Reference Sections	Notes
Software Performance Validation Matrix	RD 11-1	11.2.4	
Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) Results	RD 11-2	11.2.5	
Input for Software Metrics	Item 9	11.2.6	
Monthly Software Status Reports	RD 11-3	11.5	

11.1 GENERAL

The developer will have a Software Quality Management System (SQMS) that is compliant with ANSI/ASQC Q9001. The SQMS will be applied to all software developed under this contract.

The developer's Quality Manual will be provided in accordance with Section 9.0 of this document. (DID 320.) The developer will allow NASA audits to assure compliance of the developer's SQMS with ANSI/ASQC Q9001 and to assure that the SQMS is applied to the contracted software activities.

11.2 QUALITY SYSTEM AUGMENTATIONS

The developer's compliant SQMS will be augmented as shown below. The reference listed below are to sections in ISO/FDIS 9000-3:1997(E) which provides guidance on the development of a SQMS that is compliant with the ANSI/ASQC Q9001.

11.2.1 Augmentation to Section 4.1.3, ANSI/ASQC Q9000-3, Joint Reviews

There will be a series of developer-presented formal reviews conducted by a GSFC-chaired review panel that will include independent experts in the type of software under review. The formal reviews will consist of, as a minimum, a Software Requirements Review (SRR), a Preliminary Design Review (PDR), a Critical Design Review (CDR), a Test Readiness Review (TRR), and an Acceptance Review (AR). These reviews will be coordinated with the reviews defined in Chapter 3. The developer will record minutes and action items during each review.

11.2.2 Augmentation to Section 4.1, ANSI/ASQC Q9000-3, Corrective Action

The corrective action process will start at the establishment of a configuration management baseline that includes the product. (Refer to Section 11.2.3.) The use of the formal software corrective action process will become mandatory with the first instance of the software's delivery to testing for the verification software requirements.

GSFC personnel will be allowed access to problem reports and corrective action information as they are prepared.

11.2.3 Augmentation to Section 4.8, ANSI/ASQC Q9000-3, Configuration management

The developer will establish a Software Configuration Management (SCM) baseline after each formal software review. (Refer to Section 11.2.1.) Software products will be placed under configuration management immediately after the successful conclusion of each review. Informal control will be used for preliminary versions of all products before it is placed under the formal SCM system.

The developer's SCM system will have a change classification and impact assessment process that results in Class 1 changes being forwarded to GSFC for disposition. Class 1 changes are defined as those that affect system requirements, software requirements, system safety, reliability, cost, schedule, and external interfaces.

11.2.4 Augmentation to Section 4.10.4, ANSI/ASQC Q9000-3, Inspection and Testing

As part of the developer's effort to verify to the Government that their software is flightworthy, the developer may be required to prepare and maintain a software performance verification matrix. If this document is prepared, an up-to date version will be provided to the GSFC Project Office upon request. (Refer to Chapter 15, RD 11-1.) If a matrix is prepared, as a minimum, it will include:

a. How each specification requirement will be verified
b. The reference source (to the specific paragraph or line item)
c. The method of compliance
d. The applicable procedure references
e Verification results
f. Report reference numbers

11.2.5 Augmentation to Section 4.10.4, ANSI/ASQC Q9000-3, Final Inspection and Testing

As part of the developer's effort to verify to the Government that their software is flightworthy, the developer and the Government will conduct a Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) on the final delivered product and on major upgrades (defined as the change of 20% or more of the lines of code) to that product upon their mutual agreement. The developer will provide the results of any audit(s) to GSFC. (Refer to Chapter 15, RD 11-2.)

11.2.6 Augmentation to Section 4.20, ANSI/ASQC Q9000-3, Statistical Techniques

The developer will provide a copy of their source code, using a format and media that will be negotiated between the developer and the GSFC Project Office. This source code will be analyzed by GSFC's Software Assurance Technology Center, using statistical techniques, to provide software metrics and an associated report for Project and developer usage. This information will provide insight into the quality of the developer's software development processes and software products. (Refer to Addendum B, Item 9.)

11.3 GFE, EXISTING AND PURCHASED SOFTWARE

If software will be provided to the developer as government-furnished equipment (GFE) or if the developer will use existing or purchased software; the developer is responsible for the software meeting the functional, performance, and interface requirements placed upon it. The developer is also responsible for ensuring that the software meets all applicable standards, including those for design, code, and documentation; or for securing a GSFC project waiver to those standards. Any significant modification to any piece of the existing software will be subject to all of the provisions of the developer's SQMS and the provisions of this document. A significant modification is defined as a change of twenty percent of the lines of code in the software.

11.4 SOFTWARE SAFETY

If any software component is identified as safety critical, the developer will conduct a software safety program on that component that complies with NSS 1740.13 "Software Safety Standard".

11.5 STATUS REPORTING

Upon mutual agreement with the Government, the developer will provide monthly status reports to GSFC to provide management insight into software development progress, issues, problems, actions taken, and schedules. This information may be included in the developer's Progress Reports to the Project or it may be a separate monthly report. (Refer to Chapter 15, RD 11-3.) Or, upon agreement with the Government, the information can instead be presented at the quarterly status reviews.

CHAPTER 12. Risk Management Requirements

12.0 OVERVIEW OF CHAPTER 12

Chapter 12 addresses the Risk Management Requirements that will be part of the System Safety and Mission Assurance Program for the GLAST Project.

The deliverable items (DID's) related to this chapter are:

Item	DID No.	MAR Reference Sections	Notes
Risk Management Plan	323	12.1	This Plan may be incorporated into the developer's PAIP.
Information Needed to Prepare Probabilistic Risk Assessment (PRA)	324	12.2	The developer will provide the required information and cooperation for GSFC to perform the analyses/assessments.
Information Needed to Prepare Fault Tree Analysis	325	12.2	
Information Needed to Prepare Risk Assessment	326	12.3	

12.1 GENERAL REQUIREMENTS

Risk Management is a requirement established by the NPG 7120.5A, NASA Program and Project Management Processes and Requirements. The development and implementation of the project-specific Risk Management Plan will aid in performing risk assessment and risk management within the reliability and quality assurance activity. (Refer to the CDRL, DID 323.) Risk Management applies to all software and hardware products and processes (flight and ground) to identify, analyze, track, and control risks and well as plan mitigation actions. The Risk Management Plan may be incorporated into the PAIP. (Refer to the CDRL, DID 301.)

The developer will:

a. Search for, locate, identify, and document reliability and quality risks before they become problems

b. Evaluate, classify, and prioritize all identified reliability and quality risks

c. Develop and implement risk mitigation strategies, actions, and tasks and assign appropriate resources

d. Track risk being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations, and anomalies

e. Control risks by performing: risk close-out, re-planning, contingency planning, or continued tracking and execution of the current plan

f. Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all levels of the project

g. Report on outstanding risk items at all management and design reviews. The GSFC GLAST Project Office, the GSFC Systems Review Office (for design reviews only), and the developer will agree on what level of detail is appropriate for each review.

All identified reliability and quality risks will be documented and reported on in accordance with the Project's Risk Management Plan. Risk status will be available to the Project for review. The status of risks will also be provided in Technical Review Reports. (Refer to CDRL DID 306.) Although not all risks will be fully mitigated, all risks shall be addressed with mitigation and acceptance strategies agreed upon at appropriate mission reviews.

Note: The GSFC Office of Systems Safety and Mission Assurance has developed training and processes to aid GSFC and NASA missions in implementing an effective Risk Management Program. This training and assistance is available upon request from the GSFC Project Manager.

12.2 PROBABILISTIC RISK ASSESSMENT (PRA)

The developer will provide all requested/required information to GSFC so that the Government can perform a Probabilistic Risk Assessment (PRA) for their hardware and software. (Refer to the CDRL, DID 324.) It will take into account a Fault Tree Analysis that the Government will also prepare with information provided by the developer. (Refer to the CDRL, DID 325.) The information required will include parts lists (Refer to the CDRL, DID 310.) and schematics. Additionally, the developer and their collaborators will cooperate with the Government as required to prepare these documents.

12.3 RISK ASSESSMENT

The developer provide all requested/required information to GSFC so that the Government can perform an on-going risk assessment of the program including flight hardware and software. (Refer to the CDRL, DID 326.) Additionally, the developer and their collaborators will cooperate with the Government as required to prepare this assessment.

CHAPTER 13. Applicable Documents List

DOCUMENT	DOCUMENT TITLE
ANSI/ASQC Q9001-1994	Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
ANSI/ASQC Q9000-3	Quality Management and Quality Assurance Standards
ANSI/IPC-A-600	Acceptance Criteria for Printed Wiring Boards
ANSI/IPC-D-275	Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
ANSI/IPC-HF 318	Microwave End Product Board Inspection and Test
ANSI/IPC-RB-276	Qualification and Performance Specification for Rigid Printed Boards
ASTM E-595	Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment
EWR 127-1	Eastern and Western Range Safety Requirements
KHB 1710.2D	Kennedy Space Center Safety Practices Handbook
NPD 8710.3	NASA Policy for Limiting Orbital Debris Generation
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components, rev A, dated June 1996
5405-048-98	Mechanical Systems Center Safety Manual
GSFC 311-INST-001	Instructions for EEE Parts Selection, Screening, and Qualification
GSFC 433-CDRL-0001	LAT Contract Deliverables Requirements List (CDRL)
GSFC 433-SPEC-0001	GLAST Mission System Specification
GSFC 731-0005-83	General Fracture Control Plan for Payloads Using the Space Transportation System (STS)
GSFC PPL	Goddard Space Flight Center Preferred Parts List
GSFC S-312-P003	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
GSFC S-313-100	Goddard Space Flight Center Fastener Integrity Requirements
MIL-STD 1629A	Procedures for Performing a Failure Mode Effects and Criticality Analysis
MIL-STD-756B	Reliability Modeling and Prediction
MSFC CR 5320.9	Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules

MSFC-HDBK-527	Material Selection List for Space Hardware Systems
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking
NASA Reference Publication (RP) 1124	Outgassing Data for Selecting Spacecraft Materials
NASA RP-1161	Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques
NHB 1700.7	Safety Policy and Requirements for Payloads using the Space Transportation System
NHB 8060.1	Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion
NSS 1740.13	Software Safety Standard
NSTS 1700.7B	Safety Policy and Requirements for Payloads using the International Space Station
NSTS 22648	Flammability Configuration Analysis for Spacecraft Applications
S-302-89-01	Procedures for Performing a Failure Mode and Effects Analysis (FMEA)
S-311-M-70	Specification for Destructive Physical Analysis

CHAPTER 14. Acronyms and Glossary

14.1 ACRONYMS

ABPL	As-Built Parts List
ANSI	American National Standards Institute
AR	Acceptance Review
ASQC	American Society for Quality Control
ASIC	Application Specific Integrated Circuits
BOL	Beginning of Life
CCP	Contamination Control Plan
CDR	Critical Design Review
CDRL	Contract Delivery Requirements List
CIL	Critical Items List
CPT	Comprehensive Performance Test
CVCM	Collected Volatile Condensable Mass
DID	Data Item Description
DoD	Department of Defense
DPA	Destructive Physical Analysis
DRP	Design Review Program
DRT	Design Review Team
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOL	End of Life
FMEA	Failure Modes and Effects Analysis
FOR	Flight Operations Review
FTA	Fault Tree Analysis
GEVS	General Environmental Verification Specification
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
GFE	Government-Furnished Equipment
GIA	Government Inspection Agency
GIDEP	Government Industry Data Exchange Program
GMI	Goddard Management Instruction
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
IAC	Independent Assurance Contractor
ICD	Interface Control Document
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
LPT	Limited Performance Test
LRR	Launch Readiness Review
MAG	Mission Assurance Guidelines
MCM	Multi-Chip Module
MO&DSD	Mission Operations and Data Systems Directorate
MOR	Mission Operations Review
MSFC	Marshall Space Flight Center
MSR	Management Status Report
MUA	Materials Usage Agreement
NAS	NASA Assurance Standard
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network

NHB	NASA Handbook
NSTS	National Space Transportation System
OSSMA	GSFC Office of Systems Safety and Mission Assurance
PAPL	Project Approved Parts List
PCB	Parts Control Board
PCP	Parts Control Plan
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PFR	Problem/Failure Report
PI	Principal Investigator
PIL	Parts Identification List
POCC	Payload Operations Control Center
PPL	Preferred Parts List
PRA	Probabilistic Risk Assessment
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QCM	Quartz Crystal Microbalance
RD	Recommended Documentation
RFP	Request for Proposal
RH	Relative Humidity
S&MA	(System) Safety and Mission Assurance
SAM	Systems Assurance Manager
SCC	Stress Corrosion Cracking
SCD	Source Control Drawing
SCM	Software Configuration Management
SCR	System Concept Review
SI-SC IRD	Science Instrument - Spacecraft Interface Requirements Document
SOCC	Simulations Operations Control Center
SOW	Statement of Work
SQMS	Software Quality Management System
SRO	Systems Review Office
SRR	Software Requirements Review
STS	Space Transportation System (Shuttle)
TML	Total Mass Loss
TR	Torque Ratio
TRR	Test Readiness Review

14.2 DEFINITIONS

The following definitions apply within the context of this document:

Acceptance Tests: The validation process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

Assembly: See Level of Assembly.

Audit: A review of the developer's, contractor's or subcontractor's documentation or hardware to verify that it complies with project requirements.

Collected Volatile Condensable Material (CVCM): The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

Component: See Level of Assembly.

Configuration: The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

Configuration Control: The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of which has been formally approved by the contractor or by the purchaser, or both.

Configuration Management: The systematic control and evaluation of all changes to baseline documentation and subsequent changes to that documentation which define the original scope of effort to be accomplished (contract and reference documentation) and the systematic control, identification, status accounting and verification of all configuration items.

Contamination: The presence of materials of molecular or particulate nature that degrade the performance of hardware.

Derating: The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

Design Specification: Generic designation for a specification that describes functional and physical requirements for an article, usually at the component level or higher levels of assembly. In its initial form, the design specification is a statement of functional requirements with only general coverage of physical and test requirements. The design specification evolves through the project life cycle to reflect progressive refinements in performance, design, configuration, and test requirements. In many projects the end-item specifications serve all the purposes of design specifications for the contract end-items. Design specifications provide the basis for technical and engineering management control.

Designated Representative: An individual (such as a NASA plant representative), firm (such as assessment contractor), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific function for NASA. As related to the contractor's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

Destructive Physical Analysis (DPA): An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

Design Qualification Tests: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either “prototype” or “protoflight” test levels.

Discrepancy: See Nonconformance

Electromagnetic Compatibility (EMC): The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

Electromagnetic Interference (EMI): Electromagnetic energy that interrupts, obstructs, or otherwise degrades or limits the effective performance of electrical equipment.

Electromagnetic Susceptibility: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

End-to-End Tests: Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

Failure: A departure from specification that is discovered in the functioning or operation of the hardware or software. See nonconformance.

Failure Free Hours of Operation: The number of consecutive hours of operation without failure the hardware and/or software (as appropriate) accumulated without an operating problem or anomaly since the last major hardware/software change (as appropriate), problem, or anomaly. Hours may be accumulated over various stages of hardware integration. (Refer to Section 4.3.5.)

Failure Modes and Effects Analysis (FMEA): A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

Flight Acceptance: See Acceptance Tests.

Fracture Control Program: A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload (spacecraft) project. Central to the program is fracture control analysis, which includes the concepts of fail-safe and safe-life, defined as follows:

a. **Fail-safe**: Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.

b. **Safe-life**: Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

Functional Tests: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

Hardware: As used in this document, there are two major categories of hardware as follows:

a. **Prototype Hardware**: Hardware of a new design which is subjected to a design qualification test program. It is not intended for flight.

b. **Flight Hardware**: Hardware to be used operationally in space. It includes the following subsets:

(1) **Protoflight Hardware**: Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance validation; that is, the application of design qualification test levels and duration of flight acceptance tests.

(2) **Follow-On Hardware**: Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

(3) **Spare Hardware**: Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

(4) **Re-flight Hardware**: Flight hardware that has been used operationally in space and is to be reused in the same way; the validation program to which it is subject depends on its past performance, current status, and the upcoming mission.

Inspection: The process of measuring, examining, gauging, or otherwise comparing an article or service with specified requirements.

Instrument: See Level of Assembly.

Level of Assembly: The environmental test requirements of GEVS generally start at the component or unit level assembly and continue hardware/software build through the system level (referred to in GEVS as the payload or spacecraft level). The assurance program includes the part level. Validation testing may also include testing at the assembly and subassembly levels of assembly; for test record keeping these levels are combined into a "subassembly" level. The validation program continues through launch, and on-orbit performance. The following levels of assembly are used for describing test and analysis configurations:

a. **Part**: A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.

b. **Subassembly**: A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.

c. **Assembly**: A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples are a power amplifier and gyroscope.

d. **Component or Unit**: A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are electronic box, transmitter, gyro package, actuator, motor, battery. For the purposes of this document, "component" and "unit" are used interchangeably.

e. **Section**: A structurally integrated set of components and integrating hardware that form a subdivision of a subsystem, module, etc. A section forms a testable level of assembly, such as components/units mounted into a structural mounting tray or panel-like assembly, or components that are stacked.

f. **Subsystem**: A functional subdivision of a payload consisting of two or more components. Examples are structural, attitude control, electrical power, and communication subsystems. Also included as subsystems of the payload are the science instruments or experiments.

g. **Instrument**: A spacecraft subsystem consisting of sensors and associated hardware for making measurements or observations in space. For the purposes of this document, an instrument is considered a subsystem (of the spacecraft).

h. **Module**: A major subdivision of the payload that is viewed as a physical and functional entity for the purposes of analysis, manufacturing, testing, and record keeping. Examples include spacecraft bus, science payload, and upper stage vehicle.

i. **Observatory**: See Spacecraft.

j. **Payload**: An integrated assemblage of modules, subsystems, etc., designed to perform a specified mission in space. For the purposes of this document, "payload" and "spacecraft" are used interchangeably. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.

k. **Spacecraft**: See Payload. Other terms used to designate this level of assembly are laboratory, observatory, and satellite.

Limit Level: The maximum expected flight.

Limited Life Items: Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

Margin: The amount by which hardware capability exceeds mission requirements

Module: See Level of Assembly.

Monitor: To keep track of the progress of a performance assurance activity; the monitor need not be present at the scene during the entire course of the activity, but he will review resulting data or other associated documentation (see Witness).

Nonconformance: A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformances fall into two categories--discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

Offgassing: The emanation of volatile matter of any kind from materials into a manned pressurized volume.

Outgassing: The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

Part: See Level of Assembly.

Payload: See Level of Assembly.

Performance Operating Time/Hours: The number of hours or amount of time that the hardware or software (as appropriated) was operated at any level of assembly or at a particular level of assembly as defined.

Performance Validation: Determination by test, analysis, or a combination of the two that the payload element can operate as intended in a particular mission; this includes being satisfied that the design of the payload or element has been qualified and that the particular item has been accepted as true to the design and ready for flight operations.

Protoflight Testing: See Hardware.

Prototype Testing: See Hardware.

Qualification: See Design Qualification Tests.

Redundancy (of design): The use of more than one independent means of accomplishing a given function.

Repair: A corrective maintenance action performed as a result of a failure so as to restore an item to op within specified limits.

Rework: Return for completion of operations (complete to drawing). The article is to be reprocessed to conform to the original specifications or drawings.

Section: See Level of Assembly.

Similarity, Validation By: A procedure of comparing an item to a similar one that has been verified. Configuration, test data, application, and environment should be evaluated. It should be determined that design-differences are insignificant, environmental stress will not be greater in the new application, and that manufacturer and manufacturing methods are the same.

Single Point Failure: A single element of hardware the failure of which would result in loss of mission objectives, hardware, or crew, as defined for the specific application or project for which a single point failure analysis is performed.

Spacecraft: See Level of Assembly.

Subassembly: See Level of Assembly.

Subsystem: See Level of Assembly.

Temperature Cycle: A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

Temperature Stabilization: The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

Thermal Balance Test: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

Thermal-Vacuum Test: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

Torque Margin: Torque margin is equal to the torque ratio minus one.

Torque Ratio: Torque ratio is a measure of the degree to which the torque available to accomplish a mechanical function exceeds the torque required.

Total Mass Loss (TML): Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

Unit: See Level of Assembly.

Vibroacoustics: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly transmitted acoustic excitation and as structure-borne random vibration.

Workmanship Tests: Tests performed during the environmental validation program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.

Witness: A personal, on-the-scene observation of a performance assurance activity with the purpose of verifying compliance with project requirements (see Monitor).

CHAPTER 15. Recommended Documentation (RD) Descriptions

RD NO.	DESCRIPTION	REFERENCES SECTIONS
1-1	Use of Multi-Mission of Previously Designed, Fabricated, or Flown Hardware	1.2
5-1	Technology Validation Assessment Plan (TVAP)	5-3
7-1	Stress Corrosion Evaluation Form	7.2.2, 7.2.6
7-2	Non-conventional Material and Lubrication Report	7.2.4
7-3	Material Waiver	7.2.5.3
7-4	Life Test Plan for Lubricated Mechanisms	7.2.7, 7.4
7-5	Materials Test Report for Fastener Lots	7.2.6.1
7-6	Fastener Control Plan	7.2.6.1
7-7	Certificate of Raw Material Compliance	7.4.1
8-1	Worst Case Analysis	8.2.3
8-2	Reliability Assessments	8.2.4
8-3	Trend Analysis	8.3.1
11-1	Software Performance Validation Matrix	11.2.4
11-2	Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) Results	11.2.5
11-3	Monthly Software Status Reports	11.5

Preface

The reference documentation (RD's) listed below are not contractual deliverables. (Note: The S&MA deliverables are listed in the LAT CDRL.) These RD's represent documentation that NASA requires on most flight programs. Although this information is not required (i.e., a formal deliverable) from the LAT developer, it is highly recommended that the developer prepare/utilize the listed documents to help ensure the flightworthiness of LAT hardware and software. In other words, NASA recommends, but does not require, the developer to prepare and utilize this documentation in the design and development of their hardware and/or software.

It is highly recommended that the developer discuss their need for preparing the documentation listed in this chapter internally and with NASA to determine if it is appropriate, necessary, and/or prudent to prepare (formally or informally) any of the items below to ensure the flightworthiness of their hardware and/or software.

In some case, NASA may request for that specific information listed in an item below be delivered to NASA, or available at the developer's site, for NASA's review to ensure the flightworthiness of a particular software or hardware item. For example, a "Material Wavier" or "Non-conventional Material and Lubrication Report" may be requested by NASA for a particular material on a LAT Materials List in order for that item or the list to be approved by NASA for flight. For other items listed below, if the developer elects to perform a WCA (for example) on a particular portion of the LAT design, NASA could request the option of reviewing the analysis for information. Or, if NASA sees a need for a WCA on a particular portion of the LAT design in order to ensure its flightworthiness, NASA might either request that the developer perform the WCA or that the developer provide the information for NASA to perform the WCA, as agreed upon by the developer and NASA.

Under no circumstances will NASA unilaterally redefine one of the items listed below as a mandatory formal deliverable item; however, NASA may state that the developer needs to provide all or part of the information required in one of the documents listed below in order for NASA to verify with confidence the flightworthiness of a hardware or software item. As agreed upon by the developer and NASA for each individual request, the information may:

a. Be delivered to GSFC or reviewed/surveyed/audited at the developer's (or one of their collaborator's) site
b. Be prepared as an informal or formal (i.e., unformatted or formatted) document, memo, electronic mail (e-mail), etc. or transmitted via a conversation
c. Include all of the information listed in the item below (e.g., a Material Waiver) or only those bits of information deemed essential for NASA's review

RD Number	1-1
RD Title	Use of Multi-Mission or Previously Designed, Fabricated, or Flown Hardware
Use	Demonstrate how existing design/hardware complies with current assurance and performance requirements, thereby eliminating the need to perform identified tasks otherwise required.
References	None
Timing/Purpose	If prepared, it should be available 60 days prior to PDR for GSFC information.
Preparation	For each identified existing design or hardware configuration considered to be in some degree of compliance with current requirements as a result of demonstrated compliance with previous requirements: a. Compare each performance, design, environmental, and interface requirement (including margins) for the GLAST Project (as delineated in other related GLAST documents) with the corresponding previous requirement. For any mission requirement or environmental difference from the previous use, either describe the modifications to be made to the hardware and/or software to meet Project requirements or provide a rationale and supporting information demonstrating why use without modification is considered acceptable. b. Compare each performance assurance requirement for GLAST with the corresponding previous requirement. Also, identify all waivers and deviations from the performance assurance requirements accepted on the previous project. For any requirement of the previous project that does not comply with the requirements of GLAST or for any previous deviation or waiver, describe what will be done to achieve compliance or provide a rationale and supporting information demonstrating why the difference is acceptable. In addition, indicate how

any modifications proposed as a result of "a" above will be shown to comply with the performance assurance requirements of this Project.

c. Compare the manufacturing information for the hardware proposed for GLAST with that of the prior hardware. This will include, as a minimum, the name and location of the manufacturer, the date of manufacture, any design changes, any changes to parts or materials, any modification to packaging techniques, and any changes to fabrication or assembly controls or processes.

d. Describe all ground and flight experience with the proposed hardware and software including a description of all failures or anomalies, their cause, and any corrective action that was taken as a result.

RD Number	5-1
RD Title	Technology Validation Assessment Plan (TVAP)
Use	Assessment of new and/or advanced packaging technologies that have not been used in space flight applications.
References	MAR Section 5.3
Timing/Purpose	If prepared, provide to the developer's Parts Control Board for review and approval within 30 days after technology selection or initiation of development. If prepared, a copy should be made available to GSFC and updates for major changes should also be made available to GSFC prior to performing validation steps, screens, and tests.
Preparation	A TVAP should be prepared for each new and advanced packaging technology being used. The TVAP describes the validation process steps used to assure that the new technology meets the performance requirements of the flight environment and application.

A TVAP should include the following as a minimum:

a. Packaging/advanced interconnection description, generic type, and manufacturer

b. Identification of TVAP validation steps, screens, and tests to be imposed to validate the technology

c. Schematics of the internal and external dimensions of the technology

d. Identification of the types of materials used in the manufacture of the technology

e. Description of the design application for the technology and critical performance parameters

Any format may be used to provide the above information; however, all submissions to GSFC should be in a computer readable form and easily printable. Updates to previously submitted TVAP's should identify changes from the previous submission. Updates should be provided whenever major changes to items 2b, 2c, 2d, or 2e occur.

RD Number	7-1
RD Title	Stress Corrosion Evaluation Form
Use	Provide detailed stress corrosion cracking engineering information required to demonstrate the successful flight of the material usage.
References	MAR Sections 7.2.2 and 7.2.6; MSFC -SPEC-522, MSFC-HDBK-527, NHB 1700.7, GMI 1700.3
Timing/Purpose	When prepared, provide to the GSFC Project Office with the Inorganic Materials Usage List 30 days before the contractor's PDR, 30 days before contractor's CDRl, and 30 days before acceptance List. Used to provide additional information to GSFC for the approval of the inorganic materials usage list.

Preparation In order to facilitate GSFC's acceptance of the developer's Material Usage List, the developer should provide the information requested on the stress corrosion evaluation form (Figure 7-2 of this document) or an equivalent developer's form. Alternatively, the information may be provided electronically. The stress corrosion evaluation form requires, as a minimum, the following information: part number, part name next assembly number, manufacturer, material heat treatment, size and form, sustained tensile stresses, magnitude and direction, process residual stress, assembly stress, design stress, static stress, special processing, weld alloy form, temper of parent weldment metal, weld filler alloy, welding process, weld bead removal (if any), post-weld thermal treatment, post-weld stress relief, environment, protective finish, function of part, effect of failure, and evaluation of stress corrosion susceptibility.

RD Number	7-2
RD Title	Non-conventional Material and Lubrication Report
Use	Provide to the GSFC Project Office for approval 30 days prior to CDR.
References	MAR Section 7.2.4
Timing/Purpose	If a compliant material is proposed for a first time usage or application in space or an application with limited heritage, it is considered a non-conventional material application and a non-compliant material. For example, a beryllium instrument frame or a silicone carbide spacecraft structure are non-conventional applications. This report is then used to provide additional information to GSFC for the evaluation of the non-conventional material or lubricant usage.
Preparation	A non-conventional material application report or presentation should contain: a. Description of the application b. Thermal, stress and fracture analysis c. Heritage and test environment d. Rationale for not using a conventional material application with extensive heritage e. List of chemical and mechanical materials properties available and needed for design f. Extreme environments such high stresses, temperature, corrosive environments, high atomic oxygen fluxes at low earth orbit.

RD Number	7-3
RD Title	Material Waiver
Use	For usage evaluation and approval of a material that has exceeded its shelf life or expiration date.
References	MAR Section 7.2.5.3
Timing/Purpose	A waiver should be submitted for approval of uncured polymers that exceeded their expiration date or for flight approval of cured polymers and lubricated mechanism that have a limited shelf life. When prepared, provide to the GSFC Project Office for approval 30 days prior to the CDR or use.
Preparation	For uncured polymers, the mechanical and physical properties of polymer or paint samples should be measured and recorded from the same batch of material. A sample and/or test data for identical expired, uncured polymer or paint should be submitted to GSFC to demonstrate/verify that the cured paint or polymer is acceptable for flight. For lubricated mechanisms and old polymer products such as o-rings, propellant tank diaphragms, seals dampers and tapes; mechanical and physical property data, test results, and heritage performance information should be submitted to GSFC to demonstrate the flight acceptability of the hardware.

RD Number	7-4
RD Title	Life Test Plan for Lubricated Mechanisms
Use	For evaluation of all lubricated mechanisms.
References	MAR Sections 7.2.7 and 7.4
Timing/Purpose	If prepared, provide to GSFC 30 days before PDR, 30 days before CDR, and 30 days before acceptance of the lubricated mechanism for flight.
Preparation	The Life Test Plan for Lubricated Mechanisms should contain: a. Table of Contents b. Description of all lubricated mechanisms, performance functions, summary of subsystem specifications, and life requirements c. Heritage of identical mechanisms and descriptions of identical applications d. Design, drawings and lubrication system utilized by the mechanism

e. Test plan including vacuum, temperature, and vibration test environmental conditions of the test
f. Criteria for a successful test
g. Delivery of test hardware to GSFC after a successful test
h. Final Report.

RD Number	7-5
RD Title	Material Test Report for Fastener Lots
Use	For evaluation of fasteners to verify their flightworthiness.
References	MAR Section 7.2.6.1; GSFC S-313-100
Timing/Purpose	If available/prepared provide report 15 days after GSFC's request.
Preparation	As requested by GSFC, provide materials test reports for fastener applications along with information that ties the material test report to the application (e.g., parts lists and drawings).

RD Number	7-6
RD Title	Fastener Control Plan
Use	For evaluation of fasteners to verify their flightworthiness.
References	MAR Section 7.2.6.1; GSFC S-313-100, NHB 1700.7, GSFC 731-0005-83, GMI 1700.3
Timing/Purpose	If prepared, provide 30 days before the PDR.
Preparation	If prepared, the developer's fastener control plan should address the following for flight hardware threaded fasteners that are used in structural or critical applications:

a. Acquisition/supplier control
b. Documentation
c. Traceability
d. Receiving inspection
e. Testing

RD Number	7-7
RD Title	Certificate of Raw Material Compliance
Use	For information to assure acceptable flaw content, chemical composition, and physical properties of raw materials.
References	MAR Section 7.4.1
Timing/Purpose	If available, provide to the GSFC Project 15 days after request.

Preparation Provide available information pertaining to the control of raw material including sufficient information to ensure that the supplied material meets the specified requirements. The submission should indicate the subsystem or part using the material. The generic and manufacturer's designation (if any) should be provided for the material including the type of test employed to verify material composition. The provider should indicate what tests have been performed to verify physical properties and the applicable standards controlling the testing. For example, the heat treatment condition of aluminum alloys may be verified by mechanical testing or hardness and conductivity testing. The provider should also indicate what nondestructive tests have been performed, the applicable standards controlling the testing, the type of flaw detected, and the minimum detectable flaw found as a result of the testing.

RD Number	8-1
RD Title	Worst Case Analysis (WCA)

Use To assist the developer and NASA in making reliability/design decisions. It may be used as input for other reliability/risk analyses.

References MAR Section 8.2.3

Timing/Purpose When prepared, the WCA should be available to GSFC, for information, upon request including at PDR and CDR. Similarly, updates should be made available to GSFC, for information, upon request.

Preparation A WCA is performed on circuits where failure results in a severity category of 2 or higher. The most sensitive design parameters, including those that are subject to variations that could degrade performance, should be subjected to the analysis. Adequacy of margins in the design of electronic circuits, optics, electromechanical and mechanical items should be demonstrated by analyses or test or both. The analyses should consider all parameters set at worst case limits and worst case environmental stresses for the parameter or operation being evaluated. Depending on mission parameters and parts selection methods, part parameter values for the analysis typically include the following: manufacturing variability, variability due to temperature, aging effects of environment, and variability due to cumulative radiation. The analyses should be updated to account for design changes.

RD Number 8-2

RD Title Reliability Assessments

Use To assist in evaluating alternative designs and to identify potential mission limiting elements that may require special attention.

References MAR Section 8.2.4

Timing/Purpose If performed, available upon request including at PDR and CDR for information.

Preparation A reliability assessment report documents the methodology and results of the comparative reliability assessment guidelines delineated in Section 8.2.4 of this document including mathematical models, reliability block diagrams, failure definitions, degraded operating modes, trade-offs, assumptions, and any other pertinent information used in the assessment process. Note: The format of the report is not important but it should incorporate good engineering practices and clearly show how reliability was considered as a discriminator in the design process.

RD Number 8-3

RD Title Trend Analysis

Use To monitor, throughout the normal test program, parameters on components and subsystems that relate to performance stability (i.e., to any deviations from the nominal that could indicate trends). Operational personnel should continue monitoring trends throughout the mission duration.

References MAR Section 8.3.1

Timing/Purpose A list of the parameters that will be monitored should be delivered at CDR (and as updates become available) for information. Trend analysis reports should then be provided to GSFC at PER and FRR for information.

Preparation A list of the parameters that will be monitored and updates to the list and trend reports should be prepared in accordance with Section 7.3.1 of this document. Additionally, a log should be kept for each subsystem (or for the instrument) of the accumulated operating time. The log should include the following minimum information:

a. Identification
b. Serial number
c. Total operating time since assembly of unit
d. Total operating time since last failure
e. Total additional operating time projected for the unit prior to launch

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RD Number	11-1
RD Title	Software Performance Verification Matrix
Use	Used to aid in the verification of software requirements.
References	MAR Section 11.2.4
Timing/Purpose	If prepared, the first delivery should be at PDR. Subsequently, the matrix should be delivered to GSFC as it is updated for changes in requirements and verification.
Preparation	As a minimum, this matrix should include: a. How each specification requirement will be verified b. The references source (to the specific paragraph or line item) c. The method of compliance d. The applicable procedure references e Verification results f. Report references numbers

RD Number	11-2
RD Title	Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) Results
	Use Conducted to verify that the functional and performance characteristics of the software end item that were specified have been achieved. A PCA is a technical examination of the "as built" end item to verify that it conforms to existing technical documentation.
References	MAR Section 11.2.5
Timing/Purpose	If a FCA and/or PCA is performed, FCA and PCA information should be available at the Acceptance Review.
Preparation	FCA information should include a description of the tests run, number of tests run, number completed, number passed/failed/partial, listing of deviations and waivers, and identification of discrepancies outstanding from the testing, and actions to be taken to correct them. PCA information should include identification of the baseline for the "to be shipped" end item such as end item identification and listing of supporting documentation (e.g., present version and revision level). This would include such things as the software a Version Description Document.

RD Number	11-3
RD Title	Monthly Software Status Reports
Use	To report on software development progress.
References	MAR Section 11.5
Timing/Purpose	If prepared, due to GSFC on or before the 10th calendar day of each month beginning immediately after contract signing.
Preparation	The report will address the status of the software development progress, the identification of risks with the mitigation action being taken, problems and corrective action being taken, issues, and schedules.

ADDENDUM A: Ground Data Systems Assurance Requirements

This addendum will be negotiated between the developer and the NASA/GSFC. It will be modeled after Chapter 12 of the GSFC MAG. Thus, it will cover:

1	Introduction
2	General
3	GFE, Existing and Purchased Software
4	Hardware
5	Validation
6	Testing
7	Corrective Action
8	Reviews
9	Configuration Management
10	Electromagnetic Compatibility Control
11	Reliability and Availability
11.1	Reliability Allocations
11.2	Reliability Prediction
11.3	Failure Mode Effects and Criticality Analysis (FMECA)

ADDENDUM B: S&MA DELIVERABLES NOT COVERED IN THE CDRL

The following items will be called out in future LAT contract and are referenced throughout this MAR. They are listed here for clarification/information only.

ITEM NO.	DESCRIPTION	MAR REFERENCE SECTION
1	Operations and Support Hazard Analysis (O&SHA)	2.1, 2.2
2	Hazard Control Verification Log	2.2
3	Safety Assessment Report (SAR)	2.2
4	Ground Operations Plan (GOP) Inputs (to Spacecraft Contractor)	2.2
5	Performance Verification Procedure	4.2.2
~~6~~	Verification Reports	4.2.3
6	Instrument Performance Verification Report	4.2.3
7	Printed Wiring Board (PWB) Coupons	5.2
8	Parts Stress Analysis	8.2.2
9	Input for Software Metrics	11.2.6

ITEM 1: Operating and Support Hazard Analysis (O&SHA)

Title: Operating and Support Hazard Analysis (O&SHA)	CDRL No.: Not applicable at this time (n/a)
Reference: MAR Section 2.1	
Use: Evaluates activities for hazards or risks introduced into the system by operational and support procedures and evaluates the adequacy of operational and support procedures used to eliminate, control, or abate identified hazards or risks.	
Related Documents: EWR 127-1	
Place/Time/Purpose of Delivery: The first delivery is due at CDR. An updated delivery is due to support final MSPSP delivery to the Range which in turn supports the Mission Approval Safety Review (120 days before launch). GSFC will approval all deliveries/versions.	
Preparation Information: Refer to Appendix 1B of EWR 127-1 for guidance on performance of an O&SHA.	

ITEM 2: Hazard Control Verification Log

Title: Hazard Control Verification Log	CDRL No.: n/a
Reference: MAR Section 2.1	
Use: Used to document the instrument safety assessment such that it reflects how the instrument design demonstrates compliance with the safety requirements.	
Related Documents: EWR 127-1	
Place/Time/Purpose of Delivery: Initially generated to document results of hazard analyses and updated as analysis results warrant. It will be made available to Range Safety upon request. Delivery shall support the spacecraft contractor's MSPSP submittal schedule. The final MSPSP will be submitted to Range Safety at least 45 calendar days prior to hardware shipment to Range. Preliminary shipment will be TBD based on negotiation between the spacecraft contractor and the Range. GSFC will approve all deliveries/versions.	
Preparation Information: Refer to Appendix 1B.1 of EWR 127-1 for preparation directions.	

ITEM 3: Safety Assessment Report (SAR)

Title: Safety Assessment Report (SAR)	CDRL No.: n/a
Reference: MAR Section 2.1	
Use: The Safety Assessment Report (SAR) is used to document a comprehensive evaluation of the mishap risk being assumed prior to the testing or operation of a system. The SAR will be provided to the Spacecraft Contractor as an input to their preparation of the Missile System Prelaunch Safety Package (MSPSP), which is one of the media through which missile system prelaunch safety approval is obtained.	
Related Documents: EWR 127-1	
Place/Time/Purpose of Delivery: SAR delivery shall support the spacecraft contractor's MSPSP submittal schedule. The final MSPSP will be submitted to Range Safety at least 45 calendar days prior to hardware shipment to Range. Preliminary shipment will be TBD based on negotiation between the spacecraft contractor and the Range. GSFC will approve all deliveries/versions.	

Preparation Information:

The Safety Assessment Report will identify all safety features of the hardware, software, and system design as well as procedural, hardware, and software related hazards that may be present in the system being acquired. This includes specific procedural controls and precautions that should be followed. The safety assessment will summarize the following information:

1. The safety criteria and methodology used to classify and rank hazards plus any assumptions upon which the criteria or methodologies were based or derived including the definition of acceptable risk as specified by Range Safety
2. The results of analyses and tests performed to identify hazards inherent in the system including:
   - Those hazards that still have a residual risk and the actions that have been taken to reduce the associated risk to a level contractually specified as acceptable
   - Results of tests conducted to validate safety criteria, requirements, and analyses
3. The results of the safety program efforts including a list of all significant hazards along with specific safety recommendations or precautions required to ensure safety of personnel, property, or the environment. **NOTE:** The list shall be categorized as to whether or not the risks may be expected under normal or abnormal operating conditions.
4. Any hazardous materials generated by or used in the system
5. The conclusion, including a signed statement, that all identified hazards have been eliminated or their associated risks controlled to levels contractually specified as acceptable and that the system is ready to test or operate or proceed to the next acquisition phase
6. Recommendations applicable to hazards at the interface of Range User systems with other systems, as required

ITEM 4: Ground Operations Plan (GOP) Inputs

Title: Ground Operations Plan (GOP) Inputs (to Spacecraft Contractor)	CDRL No.: n/a
Reference: MAR Section 2.1	
Use: Provides a detailed description of hazardous and safety critical operations for processing aerospace systems and their associated ground support equipment. Along with the MSPSP, the GOP is the medium through which missile system prelaunch safety approval is obtained.	
Related Documents: EWR 127-1	
Place/Time/Purpose of Delivery: The draft GOP is to be provided to Range Safety 45 days prior to the spacecraft PDR and CDR. The final GOP is to be submitted 45 days prior to hardware delivery to the Range. Inputs to this plan need to support this delivery date and must be approved by GSFC.	
Preparation Information: Refer to Appendix 6A of EWR 127-1 for preparation directions.	

ITEM 5: Performance Verification Procedure

Title: Performance Verification Procedure	CDRL No.: n/a
Reference: MAR Section 4.2.2	
Use: Describes how each test activity defined in the Verification Plan will be implemented	
Related Documents None	
Place/Time/Purpose of Delivery: 30 days prior to the start of the testing for GSFC approval.	
Preparation Information: Describe the configuration of the tested item and the step-by-step functional and environmental test activity conducted at the unit/component, subsystem/instrument, and payload levels. Give details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, pass/fail criteria, data collection and reporting requirements. Address safety and contamination control provisions. A methodology will be provided for controlling, documenting and approving all activities not part of an approved procedure and establish controls for preventing accidents that could cause personal injury or damage to hardware and facilities.	

ITEM 6: Verification Reports

Title: Verification Reports	CDRL No.: n/a
Reference: MAR Section 4.2.3	
Use: Summarize compliance with system specification requirements and/or provide a summary of testing and analysis results, including conformance, nonconformance, and trend data.	
Related Documents: None	
Place/Time/Purpose of Delivery:	
Verification Reports:	Preliminary - 72 hours after testing for GSFC information Final - 30 days after verification activity for GSFC information
Instrument Performance Verification Report:	Preliminary - At CDR for GSFC information Final - 30 days following on-orbit check out for GSFC information
Preparation Information: Verification Report: Provide after each unit/component, subsystem/instrument, and payload verification activity. For each analysis activity the report will describe the degree to which the objectives were accomplished, how well the mathematical model was validated by the test data, and other significant results. Instrument Performance Verification Report: Compare hardware/software specifications with the verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem.	

ITEM 7: Printed Wiring Board (PWB) Coupons

Title: Printed Wiring Board (PWB) Coupons	CDRL No.: n/a
Reference: MAR Section 5.2	
Use: For independent evaluation of the quality of PWB's used in the hardware	
Related Documents: IPC-D-275, GSFC S-312-P003, ANSI/IPC-HF 318, ANSI/IPC-A-600, NASA RP 1161	
Place/Time/Purpose of Delivery: Provide to the GSFC Project Office for approval as a precondition to board population.	

Preparation Information:

Provide a test coupon for each PWB used in the flight hardware and note the following:

a. The coupon will be per the design requirements of GSFC S-312-P-003 and will only be removed from the flight PWB panel after the panel has been through all manufacturing processes.

b. The coupon will be "as produced" by the vendor; that is, it will not have seen any processes not experienced by the PWB panel (including metallographic preparation techniques or thermal excursions).

c. The coupon will be clearly identified with the part number, serial number, vendor identification and date code or production lot number.

d. The paperwork accompanying the coupon will include the part number, serial number, vendor identification and date code or production lot number as well as the flight experiment to which the coupon pertains and the shipper identification and tracking number.

e. A fax will precede the coupon receipt by one day. This fax will be sent to the evaluation lab, and will include the part number, serial number, vendor identification and date code or production lot number as well as the flight experiment to which the coupon pertains and the shipper identification and tracking number.

Two weeks prior to shipping the coupons, the hardware provider will notify the Flight Assurance support contractor or the independent evaluation laboratory of the coupons that they plan to ship for evaluation.

Flight PWB will not be assembled prior to notification that the representative coupon has passed laboratory evaluation by the GSFC-approved laboratory.

The System Assurance Manager for the project will be provided with a preliminary fax of the coupon test results and the final report.

A list of certified laboratories, their addresses and phone and fax numbers will be provided by the GSFC Materials Engineering Branch.

ITEM 8: Parts Stress Analysis

Title: Parts Stress Analyses	CDRL No.: n/a
Reference: MAR Section 8.2.2	
Use: Provides EEE parts stress analyses for evaluating circuit design and conformance to derating guidelines.	
Related Documents: NASA Parts Selection List	
Place/Time/Purpose of Delivery: The analysis is due 30 work days before CDR for GSFC review at the developer's facility. Updates as required, with any changes clearly indicated, are to be available at the developer's site for GSFC review.	
Preparation Information: The stress analysis report will contain the ground rules for the analysis, references to documents and data used, a statement of the results and conclusions, and the analysis worksheets. The worksheets, at a minimum, will include part identification (traceable to circuit diagrams), environmental conditions assumed, rated stress, applied stress, and ratio of applied-to-rated stress.	

ITEM 9: Input For Software Metrics

Title: Input for Software Metrics	CDRL No.: n/a
Reference: MAR Sections 11.2.6	
Use: The resulting metrics will provide insight into the quality of the developer's software development processes and software products.	
Related Documents: None	
Place/Time/Purpose of Delivery: The developer will provide a copy of their source code, using a format and media that will be negotiated between the developer and the GSFC Project Office. This source code is provided for information and will be analyzed by GSFC's Software Assurance Technology Center, using statistical techniques, to provide software metrics and an associated report for Project and developer usage. A copy of the source code is due to GSFC 10 work days before each LAT Quarterly Review or as otherwise agreed upon with the GLAST Project.	
Preparation Information: The source code will be provided to the GSFC Project Office using a format and media that will be negotiated between the GSFC and the developer.	